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ABSTRACT

Ten units which focus on subject-matter knowledge about energy and on the logic and strategy of problem-solving within science are provided in this user's guide. Each unit includes: a detailed summary of unit problems and activities; recommended grade levels and subject areas; possible learner outcomes and general goals; teacher background information; suggested teaching strategies; suggested learner strategies (small-group discussion, large-group discussion, research, classroom experiments, and demonstrations); student data sheets (when applicable); suggested evaluation questions; and a list of resources on which activities are based. Areas explored in the units are: (1) solid state physics (energy transfer); (2) heat containers (insulative properties of thermal cups); (3) problem-solving activities related to 14 questions about energy (Does hot water freeze faster than cold water? Does the state of matter influence its ability to hold heat? Can you make electricity using a magnet and a coil?); (4) energy changes; (5) energy cells; (6) thermal expansion and other energy characteristics (using hot dogs); (7) thermal patterns in snow, frost, and dew; (8) solar collectors; (9) heat transfer; and (10) energy concepts related to toys. (JN)

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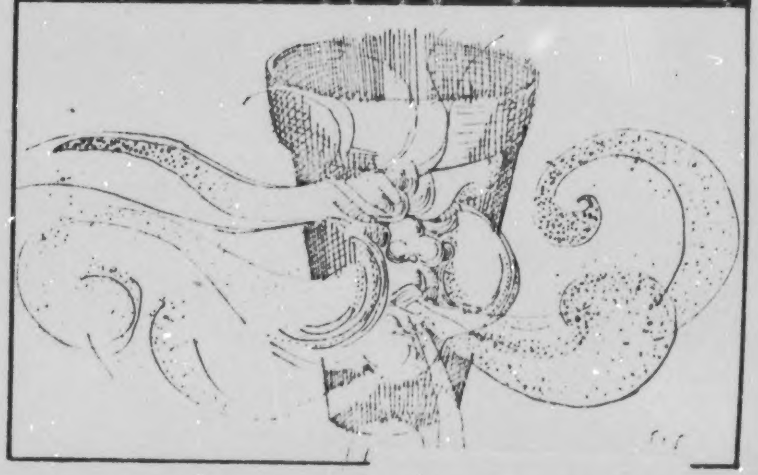
A PORTFOLIO OF ENERGY IDEAS

SCIENCE



A COOPERATIVE PROJECT INVOLVING:
- MN. DEPT. OF EDUCATION
- MN. ENERGY AGENCY
- MN. ENVIRONMENTAL EDUCATION BOARD

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A BRIEF USER'S GUIDE

INTENT: These materials are not recipes for science energy education. If their purpose could be reduced to a single statement it would include a comment about an essential and difficult task of science education: helping students learn how to turn science questions/problems about energy into experiments. So, these materials deal with learning about what a problem is, using and acquiring skills of investigation and the kind of reasoning that one does in science.

These units are only part of the science-energy education answer to the present and emerging energy dilemma. They focus on subject-matter knowledge about energy and on the logic and strategy of problem solving within science.

THE UNITS: 10 in number. . .teacher focused. . .a detailed summary which describes problems and activities is found at the beginning of each unit. . .appropriate grade levels and classes are indicated. . .possible learner outcomes and general goals are suggested. . .teacher background and an array of suggested teaching strategies are included. . .diverse learner strategies — small-group discussion, larger group discussion, research, classroom experiment, demonstrations — are used. . .student data sheets are provided where appropriate. . .suggested evaluation questions are included. . .each unit has a list of resources on which the activity is based or which you may find useful to have in your classroom.

Edward Hessler

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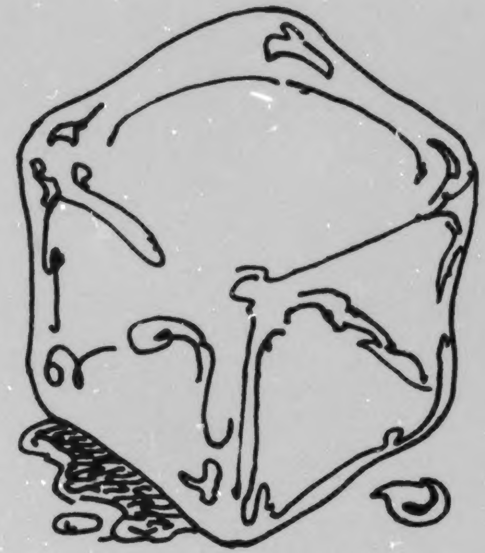
WHAT IT'S ABOUT

Students are given a simple assignment: tomorrow they are to bring an icecube to class in a homemade cube carrier. This out-of-class activity is a good way to introduce a unit on energy or energy transfer. Because energy transfer is an inexplorable process, attempts at its prevention provide many insights into the nature of energy and energy processes. This is a short unit which introduces students to the nature of an experiment, variables and "hands-on" problem solving.

Grade Levels: Junior-Senior High — **All** Science Classes



ENERGY CONTENT AND STUDENT OUTCOMES: Some Notes On This Unit

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement in it? Clearly, teachers are in the best position to decide what knowledge what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences;and it is also dependent on the classroon management of the process.

SOME BACK/GROUND NOTES

Water is a liquid between 0°C (32 F) and 100 C (212 F), solidifying at the lower figure and vaporizing at the upper. When water turns to ice, for example, in the freezing compartment of a refrigerator, it loses energy, acting as an energy source. When ice is being used for cooling,the energy which was lost during freezing is taken up by the ice causing it to melt.

Most of us take ice for granted. One remarkably successful group of humans which has not are the Eskimos who have made a ceaseless study of ice. They are experts in ice lore and those of us who know little of it can learn much about the winter environment from them. However, we can also learn to watch ice, experiment with it, discover some of its secrets, and, by so doing, gain some important insights into energy events to which, on a much broader scale, we must respond to maintain our existence.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Changes of state	*Changes brought about by the interaction of matter and energy.	*Ability to distinguish observations which are relevant to the solution of a problem from those which are not.	*Willingness to consider the results from a previous experiment.	*All changes of state involve energy.
Changes and energy	*That energy can be stored.	*Ability to separate, exclude or combine variables in approaching problems.	*Willingness to consider the role of science in everyday life.	*Energy is taken in or given out during energy transformations.
	*Properties of heat.		*Enjoyment in developing methods for solving problems.	*In order to change from a solid to a liquid to a gas, energy has to be supplied.
	*Conditions which promote and inhibit changes.			
	*Some factors need to be considered when choosing a material for a practical use.			

ACTIVITY

At the **end** of a class period make the following announcement to your class: "Your assignment for tomorrow is to bring an ice cube to class in a homemade carrier."

On Carrying the Ice

A Teacher/ing Note:

Day 1: The Assignment

Be sure students understand the nature of the assignment **and** your seriousness about it. You may have to repeat it (Several times!)! You are presenting them with a problem; one which **they** must solve. Don't tell them how to do it! The challenge is clear: outsmart energy flow (if you can)!

Student response will probably include: (1) confusion; (2) looks of utter disbelief; (3) anger about the lack of directions; (4) statements such as 'This isn't science" or "you gotta be kiddin; I don't have time to do that"; and (5) a willingness by some to tackle the problem. So, be prepared!

Day 2: The Grand Opening: A De/Briefing of the Activity

When students investigate problems and produce solutions—especially when the problem is as exploratory a trial or probe as this one— a discussion of points relevant to the problem must be considered. Response is a key feature of the process. Because all of your students have thought about and tried to solve the problem at about the same time, including those who for one reason or another didn't do it, you will be taking advantage of an enormous pool of observations, solutions and possible interpretations. Students are problem solvers although they need help in learning to deal with problems. There are many problem-solving skills in this assignment: Students choose a design solution from alternatives; make projections; decide on the parts which their solution must contain; etc.

Discussion can help students make their own sense out of the experience. A skillfully maintained discussion can help students learn to ask better questions and listen to each other. Furthermore, when you have a number of alternative explanations, disagreement is sure to follow. This situation offers an opportunity to resolve differences through the reconsideration of evidence.

- Have students present their results. Tally them—successful, unsuccessful. How successful was the class? Calculate a percent and give yourselves a grade.
- Decide what variables* constitute a success, e.g., length of time ice cube survives; length of time ice cube survives at a more-or-less constant outside temperature; distance ice cube travels; etc.
- What are the properties of successful ice cube carriers? Of unsuccessful ice cube carriers? Try to organize this information into the key properties of a successful ice cube carrier.
- What might account for the changes that occurred in the ice cube?
- If you want to use a written report have students provide you with five kinds of information: (1) Is there a change?; (2) What is changing?; (3) Evidence of interaction**; (4) The inferences*** that they can make; and (5) the sequence of events from the time they place the ice cube in the container to the time it was opened.

- Describe the ice cube carrier as a system****. Students may need some help with this notion:
  - What are its parts
  - What are its variables?
  - What are the values of the variables? (How are they measured? Weight? Length)height measurements? Color?)
  - What are the relevant variables? (What ones will help you notice whether a change occurs? What differences will you accept as evidence of interaction or a change in relationship in the system?)
  - When do you make the observations?
  - What are the conditions for making the observations? (What will be measured? How will it/they be measured? What comparisons will be made?)

* variable: A property that can appear in distinctively different values.

** interaction: Relationships amound parts. Evidence may include gains of losses or differences in the variables.

*** interferences: tentative conclusions; what might account for the changes that occurred.

**** system: Any set of objects or variables among which a relationship exists.

Turn/ing a Problem Into An Investigation

Present your students with a new assignment: "You are designers at Portacube, Inc. Modify the solid state carrier so that it gives a better performance."

Some suggestions for helping them decide what to do follow.

- It is important for you to know how long your ice cube lasted in your previous attempt? Why/Why not? How would you find out?
- What variables make up a successful performance for the second ice-carrier? E.g., the length of time that the ice cube lasts; making the ice cube last an hour longer; meeting the expectation of the assignment; exceeding the expectation of the assignment; etc.
- Decide how to measure these variables.
- What variables might influence a good carrier? E.g., the wall materials; cube coldness (made in a deep freeze vs. refrigerator freezer); an aluminum foil liner; the presence of a dead air space between the inside and the outside of the container; tinted (vegetable dye) water; freezing the cube with an aluminum foil lining and cover; the rate at which a cube freezes; whether the cube is made from warm water or cold water; a cube made of a sugar and salt solution; do two (or more) ice cubes make a difference or a larger ice cube (are the last two the same experiment?); etc?
- Decide which variables are relevant. Can/should you deal with all of them? Is it better to systematically manipulate one variable (independent variable) and see how if affects another variable (dependent variable)?

- Hypotheses play an important role in science. They are one of the most important ways that scientists obtain wanted data. Urge (insist that?) your students to make use of them. But what is a hypothesis? One way for kids to think about hypotheses are as tentative explanations. They are to be viewed as research and discovery guides.

In the experimental sciences, hypothese often take a special form. They begin with an **if** statement followed by a second statement which begins with **then**. "If. . ., then. . ." reasoning is important because it helps to focus the research. **If** an ice cube is placed inside a double-walled styrofoam insulated cube carrier, **then** the cube will last twice as long as it did in the original container.

The next step is to test the hypothesis. The information (or data) students collect will either support or not support the hypothesis. However, the answers are most often never quite final. As patterns are exposed, the very best students can do — is make inferences. Data which support the hypothesis can lead to answers which are tentative. Of course, some are stronger than others but most answers are only probably true. A better answer may be found. A reason for this is that there are usually so many sources of variation that there is always a risk in reaching a conclusion.

What about the data that does not support the hypothesis? Does this mean that hypothesis is wrong? Not necessarily! It is quite possible that the data is wrong—mistakes in recording, methods used to obtain data, etc.

- How many successful trials are enough? How much variability is there in outcomes? Be sure to emphasize that students keep records of their work. It may be possible to graph some of the data.
- What are the performance data on the best model you achieved? The class achieved? What accounts for some of the variation observed?

AFTER/WORDS

1. It is said that ice kept frozen in a wet piece of paper keeps frozen longer than an unwrapped piece of ice. Do you think that this is true? What are some of your reasons? Turn this question into an experiment and see whether it is.
2. Which one of the following best explains the way ice chests work? Explain your answer.
   a. the coldness of the ice______________________________
   ____
   b. The fact that ice acts as an energy receiver________________
   ____

3A. When ice melts, water formed by melting
   a. is less than 0°C
   b. is more than 0°C
   c. remains close to 0°C

B. As ice melts, the temperature of the remaining ice
   a. is less than 0°C
   b. is more than 0°C
   c. remains close to 0°C

RE/SOURCES

Ferris, Deborah. 1979. Sold-State Transport: The Fine Art of Ice Keeping. Learning, May/June, p. 57

Schwab, Joseph J. (Supervisor). 1963. Biology Teachers' Handbook.
John Wiley and Sons,Inc., New York. (Most schools and/or biology teachers have this book. There is a discussion of the role of hypotheses in science which you may find useful. The examples are all biological).

HEAT CONTAIN/ERS

WHAT IT'S ABOUT

Do thermal cups (especially the white, foamy, plastic ones) really work? In this activity students study this problem scientifically and reach a conclusion based on their research. This unit assumes that students have had some experience with experimental design; if not, perhaps you will want to consider another energy activity. There are two activities: one explores the insulative properties of plastic foam cups and the other considers an entire system—cream, cover, sugar, cup color, etc.

Grade Levels: Junior High — Earth Science, Physical Science

HEAT CONTAIN/ERS

ENERGY CONTENT AND STUDENT OUTCOMES: SOME NOTES ON THIS UNIT

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement in it? Clearly, teachers are in the best position to decide what knowledge, skills and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives it probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

HC 2

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Devising experiments or investigations to answer questions about energy	*Energy can be stored and converted in a variety of ways.	*Identify the essential steps in converting a question into a scientific problem.	*Willingness to examine evidence critically.	*Interpreting findings critically.
	*Some properties of heat energy.	*Ability to design an experiment for testing an hypothesis.	*Willingness to consider the role of scientific problem solving in everyday life.	*Posing questions and devising experiments to answer them.
		*Measurement accuracy has to be taken into account when results are interpreted.	*Willingness to suggest hypotheses.	*Developing a scientific approach to problems.
		*Ability to use graphs for recording results.	*Willingness to communicate to others what they have found in solving a problem	
		*Ability to select the graphical form most appropriate for the information being recorded.		
		*Ability to use quantitative data to answer a question.		
		*Make and test hypotheses.		

SOME BACK/GROUND NOTES

Cups. . .white. . . soft. . . light . . . foamy. . . extruded plastic. Made from petroleum? Why do we use them? Does it say something about us? What are our real choices? Are they for the energy conscious? Or Unconscious?

Plastic cups are found almost everywhere. Their habitat is restaurants with carry-out service, fast-food chains, picnics (Gettin' Close to Nature!) and especially, and embarassingly, wherever environmentalists and energy-conscious gather. The lead-off speaker never fails to mention the difference between the behavior of using the cups and the rhetoric of conservation. The speaker continues. . . a steady stream of buzz words which grab the audience. . . solid waste. . . nonbiodegradable. . . landfills. . . scarce resources. . . energy costs. . . I mean. . . tension-city. Guilt reaches a few and names are quickly written on the white cups (recycling for a day) but, even then by the end of the day a few souls own several autographed cups!

We hear such cups save money. And, yes, that they are convenient. Sometimes the value of their insulative properties is hinted at. What are those properties? Are they real? How real? Do thermal cups really work?

ACTIVITY

A Teacher/ing Note 1: Experimental Design

It is assumed that your students have had some experience in experimental design. While one of the characteristics of science is the asking of questions in organized ways, not all scientists/science educators organize that search in the same way. There is also a wide range of differences between science disciplines in the use of scientific procedures. The short notes that follow refer to vocabulary words used on the student cards.

About Hypotheses

A hypothesis is not an answer—it is a guess at an answer. There is no such thing as a wrong hypothesis. It's "rightness" or "wrongness" is determined by the test of the evidence. A hypothesis may be irrelevant to the problem in the sense that the data needed to test it are not available, but it cannot be wrong.

The hypothesis directs the search for evidence. It helps determine which of the large pool of information or data available to us may be used as evidence.

Hypotheses in science as well as in the social sciences often take a special form: an **IF** statement, the factor which the researcher varies, is followed by a **THEN** statement, the result. The factor following the **IF** is the part that can be changed by the investigator or the variable. The **THEN** changes as the **IF** variable is changed.

For example: **IF** the water temperature is correct, **THEN** the ice will be frozen faster. In the IF part of this hypothesis one variable is mentioned: water temperature. A student investigating the influence of beginning water temperature on the rate of freezing of ice can change or vary the temperature of the water, In IF. . .THEN hypotheses only one variable should follow the IF part of the statement. In the IF part of a hypothesis, the researcher has direct control over the variable. Such variables are also called *independent variables* because they are controlled by the researcher.

Note the THEN part of the statement. It, too, mentions a single variable: ice formation. The THEN part of the hypothesis is connected to the IF statement: it changes or varies with the changes in the IF part. The investigator does not control these kinds of variables. Such variables are also called *dependent variables* because they depend on the outcome of the experimental design chosen by the investigator.

IF. . . THEN. . . statements are sometimes used—directly (less often) or indirectly (more often)—in advertising and you might ask students to find examples from newspaper, magazine, radio and television advertising. You could have students analyze some of the ads to give them experience in learning to identify **if** variables and **then** variables.

You, of course, may choose to teach students to develop and use different ways to state hypotheses. If you do, you will need to change the student cards.

On Evidence

Evidence is a special kind of information. It, in some way, has a bearing on the hypothesis being tested.

On Graphs

Because the relationship in IF. . . THEN. . . hypotheses is a functional one, the **IF** data are plotted along the horizontal (x) axis and the **THEN** data are plotted along the vertical (y) axis.

On Data

Some science educators like this word; others detest it. Maybe you would prefer to use information-the-student-collects-in-answering-questions or. . .

On Inferences

Inferences differ from **OBSERVATIONS** which are a result of our senses: what we see, hear feel, taste, etc. **INFERENCES** are explanations which are based on past experiences, cognitive processes (thought)—they are an informed guess. When students make inferences they are making all possible connections between the evidence and their hypothesis. There is often more than one inference possible. Some or one may be stronger than others but this does not necessarily mean that it is true. Inferences most often suggest new hypotheses and new experiments. Experimentation is a series of successive approximations and refinements.

FINALLY

What is being suggested in the student cards is the use of an organized approach to answering questions. **What** you will measure, what **purpose** is the measurement to serve, **how** will you measure, **when** will you measure, **what** data will you collect, **how** will you report them, **what** inferences can you make, **what** new experiments are suggested? It is up to you as the teacher and your students to decide how far to carry these assignments.

About the Student Cards

Teacher/ing Note II:

The two student cards suggest a topic area or problem from an energy-science investigation. Students are expected to organize and record their information using the categories suggested on the cards, in their laboratory notebooks. Obviously, you can use different categories. You decide on whether this activity is to be a team, individual or a special student project.

The cards suggest the only variable to be investigated is heat. Perhaps part of your class would like to investigate the insulative properties of the cups with cold liquids.

You may want to pay special attention to what students do with the data they collect. You may want to combine class data or those of several students and compare them with the results of a single experiment. It is important that they agree? Why don't they agree? Which is more valid: the results of a single experiment or the results from the pooled data? Why? How valid is the data? How sure are the students of their data? Are there patterns? Regularities? Be sure, in this discussion, that students refer periodically to the hypothesis being tested. What does the evidence mean? How is it related to other pieces of evidence? What is the relationship between the evidence and hypothesis?

Discuss ways students use graphs and tables. What were their advantages and disadvantages? Were the graph axes used appropriately? What predictions can they make from their graphs? What would the temperature be 10 minutes after the last point on the graph? Is this informed relationship true? This kind of debriefing of the experiment is important and will help your students better understand science as a process. Ask students to discuss the advantages of such procedures as well as the disadvantages.

Students are not to drink or taste any of the liquids/mixtures that they work with!

Plastic Cup

Student Card I

TEAM: ____________________ **DATE:** ____________________

Cups of light-weight, plastic foam are used for many reasons. They are said to have better insulative properties than cups made of other materials. For hot drinks they are supposed to be excellent heat holders. Do they work?

Make a hypothesis in the form of an if. . . then statement. (If you can, make two hypotheses.)

Design an experiment to test your hypothesis.

List the materials you need.

What data are you going to collect?

List you observations.

Organize your findings in your laboratory notebook.

Interpret your findings any way you wish but support them with your data.

Plastic Cup

Student Card II

TEAM: ____________ **DATE:** ____________

What is the influence of one of the following variables on the heat-holding qualities of a foamed-plastic cup? Investigate one, and find out.

Cream or milk
Artifical cream
Sugar
Stirring
Hand held or setting on a table
Cup color
Cover

Make a hypothesis in the form of an if. . . then statement. (If you can, make two hypotheses.)

Design an experiment to test your hypothesis.

List the materials you need.

What data are you going to collect?

List you observations.

Organize findings in your laboratory notebook.

Interpret your findings any way you wish but support them with your data.

MORE TO INVESTIGATE

1. The advantages of plastic thermal mugs and "glasses" are often promoted. Do they work?
2. Insulated cups were not always available. Ask people what they did "in the old days" at community meetings. What do they see as the advantages and disadvantages of "the old days" solution versus "the contemporary days" solution?

AFTER/WORDS

1. To some, plastics epitomize the ultimate in pollution. Read the following statement to your students and ask them whether they agree or disagree with it. If so, why? If not, why not?

   > "Ours is a plastic world, populated by plastic people in plastic societies cluttered with too many things made of cheap plastic"

2. Some people hold the belief that modern plastics can be blamed for:
   - Aggravating the energy crisis by directing and wasting a large share of available crude oil.
   - Adding large energy penalties to costs of consumer goods.
   - Littering the landscape with frivolous throwaways, and creating unsolvable dilemmas in sold waste disposal.

   Ask your class whether they agree with these statements and some of their reasons. Discuss their responses in the context of these 1975 data.

   - Less than 5 percent of the total world productin of petroleum is used for chemicals made from oil.Less than one?third of this total is used for plastics.

*Product	Energy Expenditure in Kilowatt Hours
Returnable beverage containers	2
Paper milk carton	18
Plastic beverage container	11

*Plastics constitute less than 3 percent of solid city waste.

Now discuss this in the context of plastic cups and plastic beverage containers. Plastics are a small part of all the wastes we create **but** they are made from non-renewable energy resources.

Are plastic foam cups an unnecessary waste of plastics? How could this be prevented? Should it be prevented? Would you eliminate all one-time only use of plastic material? Why or Why not?

3. Ask your students to find a way that plastics assist in energy conservation. There is a hitch! They must be able to provide you with some reasonable evidence!

HOT AND COLD — A BAKER'S DOZEN

WHAT IT'S ABOUT

This is a collection of open-ended energy problems which kids are to "solve." They are quite different from one another. The problems vary in difficulty. A common strategy for approaching these problems is suggested in order to encourage the teaching of problem-solving skills. It is hoped that the activities which kids select will help them learn to turn problems into experiments. The problems considered are:

a. Does hot water freeze faster than cold water?
b. What happens to the temperature of ice as it is heated, melted and steamed?
c. If a cup of hot water is mixed with a cup of cold water, what will be the final temperature of the water?
d. How accurate a thermometer is your skin?
e. Can light energy be turned into mechanical energy?
f. Can mechanical energy be turned into light energy?
g. What part of the energy put into an elastic is returned upon its release?
h. Does the water in a covered pan boil faster than the water in an uncovered pan?
i. How does the size of water sample to be cooled influence the rate of temperature change?
j. Does the state of matter influence its ability to hold heat?
k. What is the influence of tire pressure on the distance a bicycle coasts?
l. Can you make electricity using a magnet and a coil?
m. A Teacher Demonstration: The Dripping Snowball.
n. This One is For You: Experimental Design.

Grade Levels: Junior High — Physical Science

HOT AND COLD — A BAKER'S DOZEN

ENERGY CONTENT AND STUDENT OUTCOMES: SOME NOTES ON THIS UNIT

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement it it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Devising Experiments or Investigations to Answer Questions About Energy	*Of ways to investigate and measure properties.	*Ability to use scientific equipment and instructions.	*Recognition of application of science content to other areas of school and life.	*Developing an inquiring mind and a scientific approach to energy problems.
	*About variables.	*Interpreting findings critically.	*Interst in considering scientific evidence in making personal decisions.	
	*About measurements	*Ability to select graphs/tables in a form appropriate to the information being recorded.		
	*About testable and unstable questions.	*Drawing conclusions that are consistent with the data.		
	*About hypotheses.			
	*About quantitative data.			
	*Constructing explanations.			
	*That energy can be stored and converted in various ways.			
	*About properties of common forms of energy.			
	*More than one variable may be involved in a particular change.			

SOME TEACHER/ING NOTES ON:

HELPING YOUR KIDS TURN A PROBLEM INTO AN EXPERIMENT

These activities can be used in several ways. They represent some choices for kids in your classes. Their primary emphasis is on individual and/or small team science energy investigations. The activities are not highly structured and, because of their open approach, you are going to have to be ready to help students. It is hoped that the assignments are not so empty that you and your kids can't get started at all.

The *Minnesota Essential Learner Outcomes in Science* suggest an appropriate sequence in the investigation of a scientific experiment: isolating the problem; gathering data; suggesting hypotheses; developing experiments with variables and controls; interpreting results; drawing conclusions; and making predictions. Such an approach should help students in better understanding ways to attack a problem.

Some things you can do with your students is to help them clarify science approaches to problem-solving. These include:

HYPOTHESES. A hypothesis is a tentative explanation.

Help your students state hypotheses.

Some teachers like hypotheses stated in an 'if. . .then" form which is the special form often used in science (especially physical and chemical) and mathematics. **If** the concentration of the acid is increased **then** the reaction rate will increase.

You may not want your students to state hypotheses in an "if. . .then" form. You may prefer students to state their best guess as to what will happen: Yes, cold water will freeze faster than hot water **or** No, cold water will not freeze faster than hot water. You may prefer that students state at least two hypotheses. For some students you may want to ask them to compare the value of a hypothesis in an 'if. . .then" form with one in a yes-or-no form. These procedures are left up to you.

Prediction is an important element in science. Emphasize this with your kids. Before they do anything else they must first commit themselves.

VARIABLES. These are the things that change or can change. . . amounts, temperature, lengths, instruments, the way the investigator does something. . . Scientists try to choose the most important ones. Some variables are relevant while other variables are irrelevant to an experiment. Students may need help in deciding which ones to measure. You may be able to help by asking students 'What will you learn by measuring that variable?" "How sure are you that it is the appropriate or major variable?" "What will you learn about the experimental outcome through the measurement that you have suggested?"

In an **if. . . then. . .** statement there are two variables. The **if** is the one you change; the **then** variable is the one that responds to the **if** changes. The task that the laboratory scientist then faces is to hold all the other variables constant. This is a job!

The discussion of variables can lead to modifications: restatement of problems, the use of new variables, alternative approaches, etc.

RECORDING OBSERVATIONS. Tables, graphs and notebook space have been provided. The discussion of variables obviously includes an operational dimension: students must decide in specific ways to measure the variables. What do we measure? How do we measure? When do we measure? As kids work with graphs help them understand the x and y dimensions: the x-axis (horizontal) is the factor changed (the independent variable); the y-axis (vertical) is the factor which changes (the dependent variable) in response to changes in the x-axis values.

MAKING CONNECTIONS. Does the experiment support any of the hypotheses? Do other students agree with the interpretation? What new questions are suggested? What relationships have been dicovered? What conclusions can you draw? Decide how students will report their findings. Poster? Report? A lab write-up? Presentation to the class?

GETTING STARTED.

Assign activities to individuals/teams; or

Assign individuals/teams the same activity, then give them a choice of a second activity; or

Pick a few activities for individuals/teams and assign or let students choose them.

It is important that more than one student/team do each activity so that results can be compared and discussed.

Debrief: The Laboratory Post-Mortem.

You can encourage and enhance learning while kids are doing science. Access to science is greatly encouraged when conversation with kids occurs between you and them as co-learners in the experiments. The atmosphere that you create in discussing results must not be judgmental. The purpose in discussing results is integration of ideas as well as a provocation to student reasoning.

You may be interested in asking students to clearly identify the problem, then make some statements about their observations or to present their data to a class for discussion. Or asking students: to clearly identify the variables they investigated; to identify the sequence of procedures they used; to identify the evidence that they are using when they state a relationship; to state how sure they are of the results and to give you some reasons; to explain how their system works; to make additions to their answers ("Tell me more. I don't understand what you mean."); and to encourage students to listen to one another ("Marcia, do you agree with Andy?" "Carl, how would you interpret these data?").

If several kids do the activity it is not important that they agree but it is important to discuss the results. You have an opportunity to deal with the results. How much variability is there in the data? How valid are the data? How sure are the students of the data? Who is"right"? Ask students to explain differences in the results and to state some reasons for them. Did they measure the variable(s) the same way? What difference does it make? Combine the data and compare them with individual results. Can students now decide whether one is more "right" than the others? What modifications could be made to obtain more reliable or constant results between investigators?

ACTIVITIES

HERE THEY ARE!
P(ROB)L(EM!)S TO BE "SOLVED"

About The Problems

TEACHER INFORMATION:

A reasonably complete materials list is provided for each problem. Its purpose is to ease your task so that you can help kids in the process of problem solving. If you think that it interferes with this process remove it.

Students are not provided enough space on the cards to record and organize information. They are to use their laboraoty notebooks to do this. Categories are suggested.

Each assignment also has a question to be answered and at least one suggestion (MORE) for further investigation.

NUMBER THIRTEEN is a teacher demonstration. Record predictions. It should be fun.

NUMBER FOURTEEN is for you and your class to invent. As you try them please send them to: Science Specialist, Minnesota Department of Education, 550 Cedar Street, St. Paul, MN 55101. We would appreciate that.

One:

Problem: Does hot water freeze faster than cold water?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Containers
Thermometers
Cold, freezing weather
Water samples
Measuring containers (cylinders)

A Question

- Do you have any evidence that both water samples are different in any way other than temperature?

MORE

- Try this with distilled water.

BD 6

Two

Problem: What happens to the temperature of ice as it is heated, melted, and steamed?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (do your data suppport your interpretation?)

Materials

Styrofoam cups
Electric Immersion heater
Thermometer
Timer
Masser (Balance)
Ice

A Question

- How much work was done?
- How much work went to: (a) melting, (b) changing the temperature and (c) steaming the water?

Three

$\Delta s = \frac{\Delta Q}{T}$

Problem: If a cup of warm water is mixed with a cup of cold water what will be the final temperature of the water?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Styrofoam cups
Warm, cold water
Measuring cup/
Graduated cylinder
Thermometer

Materials-MORE

2 plastic bags or flask, cup
Thermometer

Questions

- Energy was________________________ (gained, lost)
- Which is the energy source? Energy receiver?
- Heat loss = heat gained (T, F). What is the reason for your answer?

MORE

- If warm and cold water are made to interact without mixing will energy be transferred?

Four

Problem: What kind of a thermometer is your skin *or* how accurate is it at distinguishing heat/temperature differences?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Containers large enough for your hands
Cold, warm and RT (room temperature) water
Blindfold?
Towel

A Question

- How temperature responsive is your skin?

MORE

- Are there other parts of your skin which are better temperature sensors? How much better?

Five

Problem: Can light energy be converted to mechanical energy?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Crookes radiometer
Light bulbs, lamp
Measuring stick

A Question

- What factors affect the rotation rate?
- Does distance from the light source
- influence the rotation rate? How?

MORE

- Compare a 75 watt bulb with a 100 watt bulb. A 75 watt bulb with a 150 watt bulb.

Six

Problem: Can mechanical energy be converted to heat energy?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Hand egg beater
Whisk
Bowl
Water
Thermometer
Wooden spoon
Timer

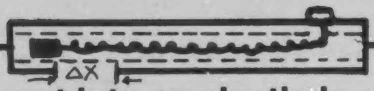
A Question

- Is this an example of friction? Why or why not?

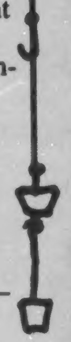
MORE

- Which provides the most convincing demonstration: warm or cold water?

Seven



Problem: What part of the energy put into an elastic is returned upon its release?



In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Rubber elastics, various sizes
Paper clip
Washers, assorted (the ones you use about 5, should) be the same mass?!)
Ruler (metric, of course)

Questions

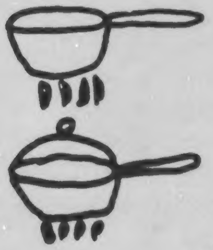
- Did you get back all of the energy that was put into the system? Be specific.
- The law of conservation of energy says ________________________
  Does this experiment support it?
- At what point does the system have the most potential energy?

MORE

- use a heavy duty rubber elastic and large masses (50-, 100-g). Stress the elastic to its limits. How does it respond now?

Eight

Problem: Does the water in a covered pan boil faster than the water in an uncovered pan?



In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Pan
Cover
Water source
Measurer
Timer

A Question

- Make a model and explain your findings. Use concepts such as latent, heat loss, convection radiation, etc., where they are appropriate.
- Is a cover an energy saver? Should people be required to use them when they are working?

MORE

- Does the addition of NaCl to the water make a difference in boiling rate?

Nine

Problem: How does the size of water sample to be cooled influence the rate of temperature change?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Ice cubes or crushed ice
Balance
Containers
Water
Thermometer
Graduated cylinder
Stirring rod

Questions

- As the amount of water is increased the temperature change will________________ .
- Account for all energy changes.
- Predict where the line for a sample 100 ml larger than your largest sample would fall on your graph. How do you know you are right?

MORE

- How does the size of water sample to be heated influence the rate of temperature change?

Ten

Problem: How does the state of matter influence its ability to hold heat? (Pick three materials to measure— one must be water).

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Test tubes
Water, cold
Gravel
Sand
Metal shavings
 (steel wool,
 others, if possible)
Container of boiling water
Thermometer
Styrofoam cups
Graduated cylinders

Questions

- Which substance has more heat capacity?
- Which substance gives up its heat fastest? slowest?

MORE

- Improve the experiment. Should you use equal volumes, equal masses, etc.?
- Try Glauber's salt, Decahydrated Sodium Sulfate ($Na_2SO_4 \cdot 10H_20$).

$C = \text{mass } H_20 \times \text{difference } (T_b, T_a)$

Eleven

Problem: What is the influence of tire air pressure on the distance a bicycle coasts?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Bicycle
Bicycle tire pump
Coasting place (Not responsible for flats!)

Questions

- What have you learned about relationship between energy conservation and tire pressure?
- How would you graph the relationship between tire pressure and coasting distance? Does each 10-pound increment in air pressure result in the same increment in coasting distance?

MORE

- Interview a garage mechanic (or several) and ask them about tire pressure recommendations made by auto manufacturers.
- Do they believe that the more pressure you put into your tires up to the stated maximum, the less gas it takes to drive a mile? Do they believe that inflating tires to their maximum makes tires last longer? Is it useful to mention whatever difference in pressure between front and back tires the owner's manual recommends? How come. . .?

Twelve

Problem: Can you make electricity using a magnet and a coil?

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

Bar magnet
Masking tape
Sandpaper
Enameled copper wire #24
Pasteboard tube
Weak Electric Current Detector (WECD)
- Galvanometer
- Microammeter
- Homemade WECD

See your teacher for Appendices 1, 2, 3

Questions

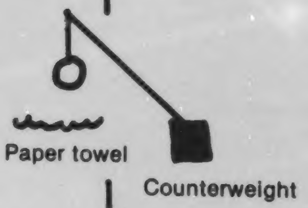
- What happens if you get the coil too close to the WECD?
- Can you predict the direction in which the WECD needle will deflect?
- Make a list of all the properties of electric current you have observed.

MORE

- Improve this apperatus so that it generates the most current (at least, more than it did originally).
- Create and design a machine to be driven by the wind which transfers the wind energy through the turning propellor into mechancial energy to drive the magnet (A 12.5 cm diameter six-bladed rotor and .4 cm (¼") bolt ought to get you started.)

Thirteen

A Teacher Demonstration



What you do: At the beginning of a class period, you (or a student) go outside and make a standard snowball around a string. Tie the string to a rod and set it on your demonstration table.

Problem: Ask your students: (1) to make a prediction! How long will it be before the first drop of water appears? (2) To explain their reasoning.

Materials

Packing snow sufficient for one snowball
String
Paper towel
Can - coffee
Lever arm
Sand/Gravel counterweight
Timing device

Questions

- Identify variables:
- Would it make a difference if the string extended through the bottom of the snowball?

MORE

- There is packing snow and, well, there is non-packing snow. How does temperature affect the manufacture of snowballs?
- How cold does it have to be before you can no longer make snowballs?

Fourteen

This one is for you. . .an energy idea to be tried which promotes an energy concept for which you teach and have kids learn • electrostatics • thermodynamics/and?entropy• net energy • calorie • heat of fusion • latent heat • the working of a household gadget (percolator • steam iron • a wok)

Problem:

In your notebook you are to state a hypothesis; design an experiment to test the hypothesis; indicate what data you are going to collect; make your experimental observations; organize your findings; and interpret your findings. (Do your data support your interpretation?)

Materials

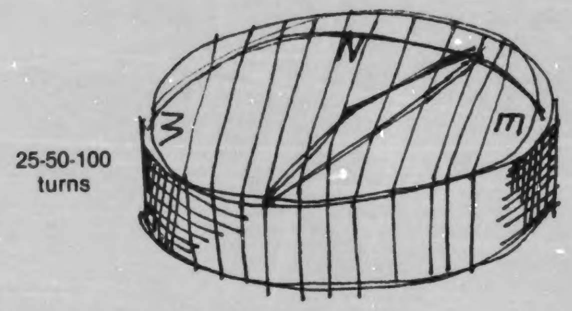
Questions

-
-

MORE

-

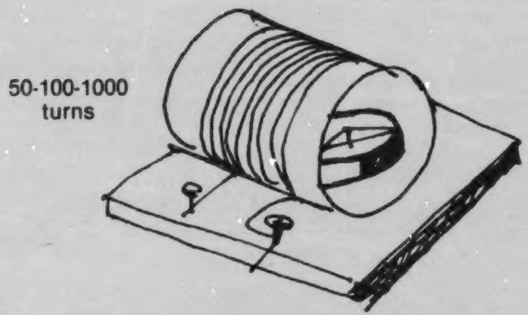
Appendix 1: Weak Electric Current Detector I, The Wraparound (WECD-I)



WECD-I

Materials
Pocket compass
Thin insulated copper wire (#24 enameled)

Appendix 2: Weak Electric Current Detector II, The Plain Cardboard Wrapper-



WECD-II

Materials
Pocket compass
Pasteboard tube to fit
Thin insulated (enameled) copper wire, #24
Wooden base
Nails, glue, tools
Alligator clips

Appendix 3: Weak Electric Current Detector II, The Shoebox Wrap (WECD-III

See plans (the second activity) in Science Activities in Energy—Electrical Energy (The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, Tennessee 37830). Someone in your school may already have them.

A CARWARMING EXPERIENCE

WHAT IT'S ABOUT

Students make some quick decisions about winter car travel as they respond to the reading of a short story. They then have an opportunity to make more informed choices. By designing and testing a fur coat for an ice cube they learn more about clothing characteristics, insulation and heat transfer. An optional activity is concerned with the design of a winter survival kit for their family car. This activity is not a complete guide to hypothermia (facts about hypothermia are included). This unit contains a variety of teaching strategies that attempt to cause students to examine energy laws and concepts and apply them to real world situations.

Grade Levels: Junior-Senior High — Life Science, Earth Science, Physical Science, Biology, Environmental Studies, Natural Resources and Conservation.

A CARWARMING EXPERIENCE

ENERGY CONTENT AND STUDENT OUTCOMES: Some Notes On This Unit

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement it it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Energy Changes	*Change is brought about by the interacting of matter and energy.	*Practice in cause-and-effect relationships.	*Appreciation of the role of science in the provision of human needs.	*Life is dependent upon energy changes and its involvement with energy.
	*Willingness to accept factual evidence despite perceptual contradiction.	*Assembly of a list of variables and choosing the best set.	*Willingness to examine evidence critically.	*Changes are reversible or irreversible.
	*Practical details of winter car travel.	*Hypothesis formation		*An awareness that living things are dependent upon one another. *Only when change takes place can use be made of energy.

SOME BACK/GROUND

Many of us lack the knowledge required for survival in a hostile environment. Just think about winter car travel! We ride in a heated box—in almost any weather—convinced that jeans, lightweight shoes, a coat and maybe gloves are enough even on a bitter winter's day.

Occasionally, for some, the experience of a car trip in a winter storm becomes a miserable experience. Searchers spend hours looking for those who lacked the knowledge to cope with the cold or who were just plain unlucky. Most searches are successful but, for a few, the experience of being trapped in blizzard conditions results in severe frostbite and, in some cases, death.

The principal cause of death is hypothermia—an abnormally low body temperature—typically 93°F (35°C) and under. A description of hypothermia is in included in Appendix 1). If allowed to continued unchecked, this temperature drop leads to death. Even a drop of two to three degrees in temperature can be serious because one of the first effects of hypothermia is a progressive inability to think clearly. In fact, a person can become seriously hypothermic without recognizing the problem early enough to take effective action. This is why prevention of hypothermia is so important.

The human body is remarkable at maintaining a constant body temperature. Food is the fuel that supplies the energy needed to perform required functions. Even at rest the body, when properly fueled, generates heat, while heat output may increase five to ten times during active exertion. The human body can lose heat in many ways: by radiation, conduction, convection, evaporation, or respiration. Conditions such as wind, moisture, and cold promote heat loss. Proper shelter eliminates or at least reduces the effects of wind and moisture. Clothing does not provide heat; it preserves the heat generated by the body.

Hypothermia can be prevented through proper food, proper clothing and proper shelter.

ACTIVITY ONE

As you read the following narrative to your class, have each student fill out the Student Score Card **(Simple Survival: What's The Score?).** When you are finished, have students fill out the chart titled: **Some Consequences of My Decision.**

Feel free to set any mood you desire before you begin. You might present the narrative as a situation to which the student must react. If kids can really feel that they are setting out on a cold journey so much the better. It may be taking matters too far if stories of fearful endurance, e.g., the polar expeditions of Peary and Scott, are used!

Narrative

Teacher

It's winter. Nighttime. Minnesota. Everything is moving. It is minus 20 degrees and forty knots of wind. You are in a four door car on an ice-spotted highway. Quite suddenly a blizzard strikes. Blinding. Raging. The weather ain't playing games.

Your car hits a patch of ice and slides into the ditch, stuck in three feet of snow. There are pictures in your mind—of Peary, Scott and Amundsen—and stories of incredible endurance. You have to make some choices. The choices you make might mean the difference between survival and extinction (see the score card below).

First of all, would you rather be alone or with someone? Three people rather than two? Four rather than three? Choose the number you'd most prefer. How many said you'd rather be alone? Two in the car? Three? Four? Five? More than five? Remember the choices you make.

How many would try to drive the car out of the ditch?

How hard would you try to drive the car out of the ditch?

How many would elect to stay stuck?

If you chose to have several in a car, would you ask them (or some of them) to get out and push? Who would do that? Who would not?

What would you rather have in your trunk—a shovel or a sleeping bag? How many for the shovel? How many for the sleeping bag?

How would you get the sleeping bag out of the trunk?

How many of you would try to walk or send help to the nearest heated building? How many would keep everyone in the car?

How many of you would shut off the engine right away? How many would keep it running?

Suppose you had a candle and a book of matches in the glove compartment. Would the candle be better to keep you warm than the car heater? Who thinks the candle? Who the car heater?

Which would you rather have to consume? A roll of salami and crackers, a quart of whipped honey, a fifth of whiskey?

If there is more than one of you in the car, how would you group yourselves? In the front and back seat? All in the back?

What would you do with the sleeping bag?

Suppose the blizzard lasts 30 hours? The gas runs out, the candle burns out, the food or liquid is all consumed. You're cold and exhausted. Would you sleep or try to keep moving about in the car?

See Appendix 2 for one answer

SIMPLE SURVIVAL: WHAT'S THE SCORE?

STUDENT SCORE CARD

Before leaving. . .

How many people would you ask to come along? ____

In the car would you rather put
  a sleeping bag ____
  a shovel ____
  a bag of sand? ____

In your glove compartment would you most want
  a box of crackers and a roll of salami ____
  a pint jar of whipped honey ____
  a fifth of whiskey? ____

Finding yourself in a ditch in a three foot snow drift would you	Yes	No
Ask someone(s) to push and try to drive out	( )	( )
Try to dig out with the shovel	( )	( )
Keep the car running	( )	( )
Bring the sleeping bag from the trunk	( )	( )
Try to flag down a car with the flashlight	( )	( )
Light the candle	( )	( )
Send someone for help or go yourself	( )	( )
Have all stay in the car?	( )	( )

If you are still in the ditch after six hours, would you rather have (rank in order of preference, 1-3)...
  the salami and crackers ____
  the jar of whipped honey ____
  the fifth of whiskey? ____

If you are still in the car after twelve hours would you
  all huddle together and try to go to sleep ____
  or
  try to do something to keep everyone awake? ____

CE 5

Some Consequences of My Decision

Fill in the Chart.

Name: ____________________

DECISION	Some Results of This Decision Are	This Will Be G = Good B = Bad	For Each Major Category the Best Choice is (✓) Because
People			
Alone			
Other(s)			
Trunk			
Bag, sleeping			
Shovel			
Bag of sand			
Glove Compartment			
Box of crackers and salami			
Pint of whipped honey			
Fifth of whiskey			
Stuck			
Push			
Dig			
Keep motor running			
Sleeping bag from trunk			
Flag a car with flashlight			
Light a candle			
Go for help			
Stay in car			
After six hours			
Salami and crackers			
Jar of honey			
Fifth of whiskey			
After Twelve Hours			
Huddle and sleep			
Try to stay awake			

Place students in groups of four and have them arrive at a consensus decision for "Simple Survival: What's the Score." They are to agree on the best decision and they must be prepared to defend their answer to the class. When they are finished help them examine their decisions. Tally the responses from "Simple Survival: What's the Score." Check out the decision-making with the class.

- Suppose you had to make your choices for survival on the basis of a majority vote. Would you have survived?
- If you said you would rather have several others with you what understandings are you depending on?
- If you sent someone out to push what are some things you forgot about?
- If you chose a shovel was it because you wanted to insulate the windward side of the car with snow?
- Would it be a good idea to try to eat before sleeping? What are the reasons?
- What are some reasons that it is always wise to tell others of your ETA (Estimated Time of Arrival) and your __________ (route, companions, supplies condition)?
- If you are in a car sitting through a snowstorm and your feet get cold what is the best thing to do?
- Suppose you did make some mistakes in choices? What was there in your heads that kept you from utilizing what every student of science knows? Were they

  Superstitions? Collect all the statements you and your class know as well as those they can find that tell us "to keep moving or you'll freeze to death" and "if you fall asleep you'll freeze." Are they fact or fiction? What keeps such myths alive?

  Fear of Uncertainty? In this situation is remaining in place as uncertain as trying to find more dependable shelter or is it more uncertain? What can we do to help us deal with uncertainty?

  Failure to Use What You Already Knew? In this case, especially what you know about science: heat radiation of warm blooded animals, reduction of friction on a slippery surface, the reduction of mobility when moving against gravity or an inclined plane; temperature change associated with energy transfer when warm and cold air systems are mixed, etc.?

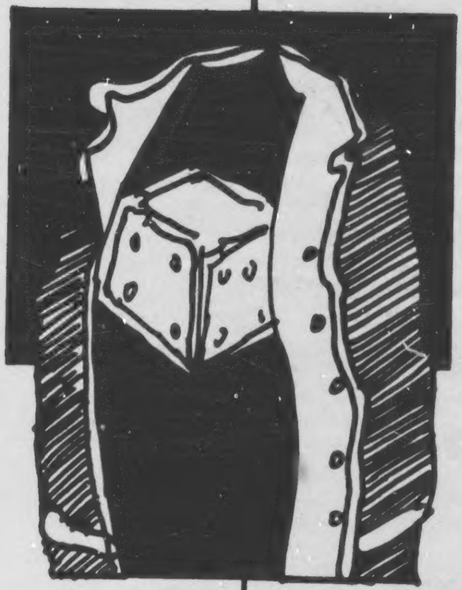
ACTIVITY TWO

Give the following assignment to your students (but before you do, read the teachering note):

Design a Coat for an Ice Cube and Prove That It Works

A Teacher/ing

Note: A Fur Coat For An Ice Cube



Clothing is not a simple matter for a winter traveler who must cope with heat-robbing combinations of wind, cold and wet. Moisture destroys the insulating properties of most clothing materials. A person dressed in wet clothes when the temperature is low may lose heat just as fast as if s/he were swimming in very cold water.

You will be presenting students with a challenge: a problem to be solved to the best of their knowledgee and ability. It is important that they understand that each of them does not have to do this the same way and that "false starts" and novel approaches are okay. Encourage the use of diverse materials.

You must be prepared to listen and watch. There is not a "right" way to do this investigation. Kids must have time to investigate and talk about their investigations. Do as much as you can to encourage students to ask questions. Expect them to be successful.

You will probably want students to go over their planned procedure before they begin their investigation. It is important that they keep a record of each investigation. The following outline is a possibility.

a. **Problem Statement or Hypothesis.**
   A widely used form has two parts: the **if** part and the **then** part. For example: If the beginning temperature of water affects the freezing time of a water sample then cold water will freeze faster. When hypotheses are stated in this form, remember that the then variable changes with changes in the if variable. In any event, you want some kind of a predicted answer to the problem under investigation.

b. **Description of procedure for obtaining the data.**
   - Materials
   - What you are going to measure.
   - How you will measure it.
   - Carry out an experimental process.

c. **Recording the results.**

d. Inferences, predictions and generalizations you can make from the data.

After the Lab: Two Post-Laboratory Experiences

1. Discuss the results with your students:
   - the variables that make up a good coat;
   - the variables that are characteristic of the most successful coats;
   - one thing students could do to produce a better performance;
   - rank the materials used from best insulator to poorest insulator.

Now Have Students Try It Again.

- Were students more successful than before? How much more successful?
- Is the range of class performance less, more or about the same as before?

2. Help your students generalize some of their findings about winter clothing.
   - Is clothing warmth directly related to fabric thickness? Are there any exceptions to this? What is the most important factor in the exceptions?
   - Is clothing warmth directly related to layering of garments?
   - Which is more important: layering or thickness? Why? How do you know? How sure are you? Devise a test and do it.

AFTER/WORDS

1. Read the following situation to your students and ask them to rank order the items from most useful (1) to least useful (5) and give them at least one reason for their choice.

> You are traveling in your camper through northeast Minnesota. A storm has begun and the radio reports it is severe and will last for two days followed by several days of blowing and drifting. The temperature is around 10°F and it is snowing hard with winds up to 40 mph. In the blinding snow your camper leaves the road, plunges over a cliff and starts on fire. Halfway down the camper is hung up on a ledge and you and your family must get out quick! The items on your list that follows are within reach. You are able to grab five of them before jumping out of the camper. The camper falls on down the cliff and the fire is extinguished in the lake below. Which of the five items will you choose and what are the reasons for your choices?
>
> **Items:**
> shovel
> transistor radio
> candy bars
> snow shoes
> large bundle of newspapers
> bottle of brandy
> bag with change of clothing for everyone
> compass
> road map
> plastic table cloth
> 30 feet of rope
> lighter with fluid
> flashlight
> can of shortening.

Most Useful Items	Reason for Choice
1.	
2.	
3.	
4.	
5.	

When they have finished, read them the answer from the article. Do they agree with it? Why/Why not?

> The question is not whether these items are useful but which five are the **most** useful. The first decision you should have made is to stay near the site of the accident and not try walking out. This conserves energy and it gives you a better chance of being found by rescuers. The decision to stay reduces the usefulness of several items on the list: snow shoes, compass, road map.
>
> Your first consideration is to keep your body warm, so the change of clothing is one item on the list. Your next consideration is for fire, and the lighter flint plus the newspaper will provide this.
>
> The newspapers will also be important for adding insulating layers to your clothing and shelter. The plastic tablecloth is useful as a waterproof barrier on the floor of the shelter, and also as the water and windproof outer layer of clothing. The final item is the can of shortening. If has food value, it can be used to protect the face against frost bite, and it is a container in which to melt snow.
>
> Ed Landin
> "How Would family Fare in Survival Situation"
> Nature's Almanac, Sunday Pioneer Press,
> February 15, 1976.
> Used with permission.

2. Based on their involvement in this activity and their research, ask your kids to make recommendations and to design a winter survival kit for their car. When they are finished compare it with the contents suggested by the Minnesota Para Rescue Team Kit (Appendix 3).
    a. In its survival courses the Minnesota Department of Natural Resources recommends a much more compact and basic survival kit for all people using the outdoors. Two of its components are:
    - Two large garbage bags. Blaze orange color is recommended for visibility, but not necessary. These are used in combination as a personal survival shelter, or, by slight modification, as a raincoat. Simply by stepping into one of the bags, then pulling the other over the head and shoulder, the camper has protection from wind and rain. It is necessary to cut a hole in the top bag so the face is exposed.
    - A whistle, the sound of which carries better than the human voice, and can help rescuers pinpoint a person's exact postion.

    Ask your students whether these should be added to their survival kits and of what value they might be.

THANKS WALLY!

Part of this activity is based on a lecture by Wally Kennedy, "Choosing for Man in the Socio-Technological Revolution," Minnesota Academy of Sciences Symposium, November 13, 1969. Used with permission of the author.

APPENDIX 1

HYPOTHERMIA

A. What It Is.

Hypothermia is an abnormally low internal body temperature—typically 95°F (35°C) and under—to a level at which the vital organs no longer function effectively. Sometimes hypothermia is referred to as exposure sickness. The following are the noted stages and symptoms of hypothermia:

Temperature C°	Symptoms
36°	Uncontrolled shivering, some mental impairment
35°	Reduced digital dexterity
34°	Shivering ceases except for periodic violent shaking spells
33°	Speech difficulty, some evidence of amnesia and some muscle rigidity
29°	Irrational behavior, a stupor state, pulse and respiration retarded
27°	Unconsciousness, reflexes cease, heart rate erratic
26°	Cardiac arrest, respiratory failure and death

B. What causes It

The greatest single factor is improper clothing. Cold, wet conditions and wind chill the body so that it loses heat faster than it produces it.

C. Where It Occurs

Hypothermia can occur anywhere that the environmental temperature is low enough to reduce the inner-core temperature of the body to the danger level. Most hypothermia accidents occur in outdoor temperatures between 30 and 50°F (-1 and 10°C).

D. How to Recognize It

Fortunately, the approach of hypothermia is noticeable by its early visible symptoms. Its onset and advance is marked by recognizable steps or stages. The warning signs which precede a hypothermia accident are:

1. A person feels cold and has to exercise to get warm.
2. The person starts to shiver and feel numb.
3. Shivering becomes more intense and uncontrollable.
4. Shivering becomes violent. There is difficulty in speaking. Thinking becomes sluggish and the mind starts to wander.
5. Shivering decreases and muscles become tight. Trembling may occur on one side of the body or in one arm or leg but no shivering. Muscle coordination becomes difficult and movements become erratic. Exposed skin does not appreciate the seriousness of the situation. However, the victim may still be able to maintain an apperance which suggests s/he knows where s/he is and what is going on.
6. The victim becomes irrational and drifts into a stupor. Pulse and respiration rates are noticeably slowed.
7. Victim falls into unconsciousness and does not respond to sounds. Most reflexes cease to function and heartbeat becomes erratic.
8. Heart and respiration centers of the brain cease functioning.

In summary, the apparent symptoms include:

- uncontrollable, shivering
- vague, slow, slurred speech
- memory lapses, incoherence
- immobile, fumbling hands
- frequent stumbling, lurching gait
- drowsiness
- apparent exhaustion; inability to get up after a rest.

E. What To Do

A person who is alert to the potential danger of hypothermia can provide self-help during stages 1-3. But, once the condition has advanced to stage 4—when the person's mind starts to wander—assistance is required. At this point, people often deny that they are in trouble. **Believe** the symptoms, **not** the victim. Treatment must be immediate:

1. Get the victim out of the cold, wind, and rain,
2. Remove all wet clothes.
3. If the person is mildly impaired—
   (i) Give the victim warm water, tea or coffee (**no** alcohol);
   (ii) Get the victim into dry clothes and a warm sleeping bag. Well wrapped warm rocks/hot waterbottles will hasten recovery;
   (iii) Build a fire;
   (iv) Keep the person quiet. Do not let the victim move.
4. If the victim is semiconscious or worse—
   (i) Try to keep the victim awake and force warm fluids;
   (ii) Place the victim stripped, in a sleeping bag with another naked person. If you have a double sleeping bag, put the victim between two warm persons; skin-to-skin contact is usually the most effective treatment;
   (iii) Build a fire;
   (iv) If you have to carry a person out, make sure that the victim's body temperature has been brought up to normal (98.6°F, 37°C) and be sure that the patient is well wrapped in a good sleeping bag.
5. When the patient recovers sufficiently the victim should be fed, dressed in dry clothing and well rested before starting out again.

F. How To Prevent Hypothermia

1. Dress appropriately. Just follow the letters, C-O-L-D: (1) C — keep your clothes CLEAN; (2) O — avoid OVERHEATING (sweating) (3) L — wear your clothes LAYERED and LOOSE; and (4) — keep your clothing DRY. Wool clothing repels wetness. Dress in layers of clothing, so some outerwear can be removed in correspondence with the activity level. An uncovered head can account for up to 60 percent of body heat loss. Carry a good wool cap. Remember the sayings: "When your feet are cold put on your hat" or "A cold brain is a numb brain"; or "Only dumbrains get numbrains"!

2. Stay dry. Wet clothing can lose up to 90 percent of its insulating value. Wool is highly recommended because it remains a good insulator even when wet. In cold weather, wet clothing extracts heat from the body nearly 200 times faster than dry clothing. Try to avoid sweating. Carry rainwear (and put it on before it actually starts raining), extra dry clothes, food and matches.
    - (i) If people travelling with you are not properly dressed and equipped, tell them. It could save their life.
    - (ii) If you are using/making a trail, travel at the speed of your lowest member. Break at frequent intervals for rest.
    - (iii) Seek shelter from the wind.
    - (iv) Keep watch on each other. It is better to turn back, cancel a trip, or concentrate on making a camp as secure and comfortable as possible, than to risk a life.

APPENDIX 2

Wally Kennedy's Answer

"If you said you'd rather be alone, you might have been so humanitarian (and so cynical) that you wanted no one else to suffer with you in this catastrophe or you might have been so victimized by a cultural myth that you take pride in loneliness. If you said you'd rather have several with you, you were counting on two understandings: that life, being interdependent, can be mutually assisting; and that mammals are warm blooded creatures whose body warmth can be radiated to the mutual sustenance of all organisms.

If you tried to drive the car out of the ditch in this blizzard, you chose to struggle against some rather solid physical facts such as the reduction of friction on slippery surface, the power of cohesion when extended across a broader surface, the reduction of mobility when moving against gravity on an inclined plane.

If you sent someone out to push, you forgot that opening a closed area mingles the internal and external temperatures and the expending energy by physical exertion decreases the caloric reserve in the blood stream. The same is true if you went outside for the sleeping bag instead of through the back seat. By the way, if you chose the shovel, I hope it was to insulate the windward side of the car with snow instead of to try to clear the snow away.

If you chose to turn off the engine you were mindful not only of the danger of carbon monoxide poisoning, but also that a candle's flame would not lower the humidity as would a heater fan, and thereby utilize the radiation increase from the moisture exhaled by living bodies.

If you kept everyone in the car huddled together under the sleeping bag in the back seat while the candle burned safely in the front seat you were conserving that mass of body temperature through a most intelligent application of science. Of course, if you elected to go tramping through the blizzard, you showed so little respect for nature that you must never have learned anything about wind chill, physical exhaustion, disorientation through limited visibility, etc., etc.

If you chose honey rather than carbohydrates and protein or alcohol, you applied what you know about chemistry and the digestive processes and replenished, in the most economical way, the caloric value lost through cold and exhaustion.

If you decided that sleeping was safer than moving about, you were applying the formost principle of evolution, **doing more with less.** You knew that having only the remaining calories in your body to preserve your life, that the relaxed sleep-state would utilize that diminishing energy best, while any exercise would waste the energy foolishly. No, you wouldn't freeze to death while asleep. You've awakened by being cold sometime in your life, haven't you?

APPENDIX 3

WINTER CAR KIT

The Minnesota Para Rescue Team

Pack in 3# Coffee Can With Plastic Cover:

(Punch 3 holes around the top edge so you can hang it from the mirror with heat can or candle on dashboard beneath it. Keep inside the car. The trunk may be jammed by collision or buried in a snowdrift. Flashlilght batteries may freeze. Warm them with your body, between your legs, under arms.)

- Work gloves/mittens, scarf and stocking cap tied on outside of can with string you'll use with;
- Bright red or orange cloth for signal banner, face mask, first aid;
- Matches and candles (stubs of dinner candles);
- Can opener
- Small, sharp knife (kitchen paring knife OK);
- Safety pins;
- Facial tissue, kitchen towels, toilet paper or paper towels;
- 2 dimes taped to cover for phone calls (25¢ pieces will work telephones and you get them back on collect calls anyway);
- Canned solid fuel or fuel tablets;
- Aspirin;
- Spoons;
- Flashlight and spare batteries (Small one does it. Reverse batteries in case to avoid accidental switching or burnout);
- Compass. (Even a toy one points north when you get away from metal. You are in bad trouble if you really need this, so think twice before you leave the shelter of the vehicle.)

FOOD (any high-calorie you'd use on an outing):

- Meat ball stew
- Honey (eat it cold)
- Semi-sweet chocolate
- Instant coffee, tea, soup
- Raisins in small packets
- Candy bars, chewing gum.

Outside The Coffee Can

Extinguisher and first aid kit should always be in passenger compartment. Transfer other items, too, for long trips or as soon as severe weather threatens.

- Sleeping bags
- Fire extinguisher
- Booster cables
- Snowmobile suit
- Snowmobile boots
- Road flares
- First aid kit
- Shovel
- Mittens
- Tow cable or chain (and know where it best hooks onto your vehicle, front and rear)
- Granite poultry grit (or sand-salt mix) in one quart plastic or paper milk cartons to spread in front of slipping rear wheels.

RE/SOURCES

Bruemmer, Fred. 1971. Seasons of the Eskimo: A Vanishing Way of Life. McClelland and Stewart, Toronto, Ontario (There are many books on Eskimo cultural adaptations and specializations to life in the Artic. This one is a beautiful combination of words and pictures. It will give students an insight into a way of life that is almost gone and may even suggest some projects. The price is $27.50. The Library of Congress Call Number is fE.E7 B78).

Nelson, Richard K. 1969. Hunters of the Northern Ice. Univeristy of Chicago Press, Chicago. (Price $3.95. Primarily an account of Eskimo hunting techniques. Includes a section on emergency conditions and drift ice survival).

Nutrition for Outdoor Recreation. (n.d.). Number 13, Minnesota Heritage Series, Minnesota Department of Natural Resources, Bureau of Information and Education, Centennial Office Building, St. Paul, MN 55155 (free).

Stewart, J. Clayton. 1975. Cold Can Do You In., Sports Illustrated, March 10.

Survival in Minnesota's Outdoors. (n.d.) Number 14, Minnesota Heritage Series, Minnesota Department of Natural Resources, Bureau of Information and Education, Centennial Office Building, St. Paul, MN 55155 (free).

A Winter Hazard for the Old: Accidental Hypothermia. (n.d.) National Institute on Aging, Bethesda, MD 20014. (free).

Winter Survival in Your Car. 1974. A leaflet by the Minnesota Para-Rescue Team, Inc. available from Minnesota Division of Civil Defense, Department of Public Safety, St. Paul, MN 55155. (free).

Winter Survival: A Consumer's Guide to Winter Preparedness. 1979 U.S. Department of Energy, Office of Consumer Affairs, Washington, DC 20585.

PILA, ELECTRONS AND GETTING INTO THE FLOW

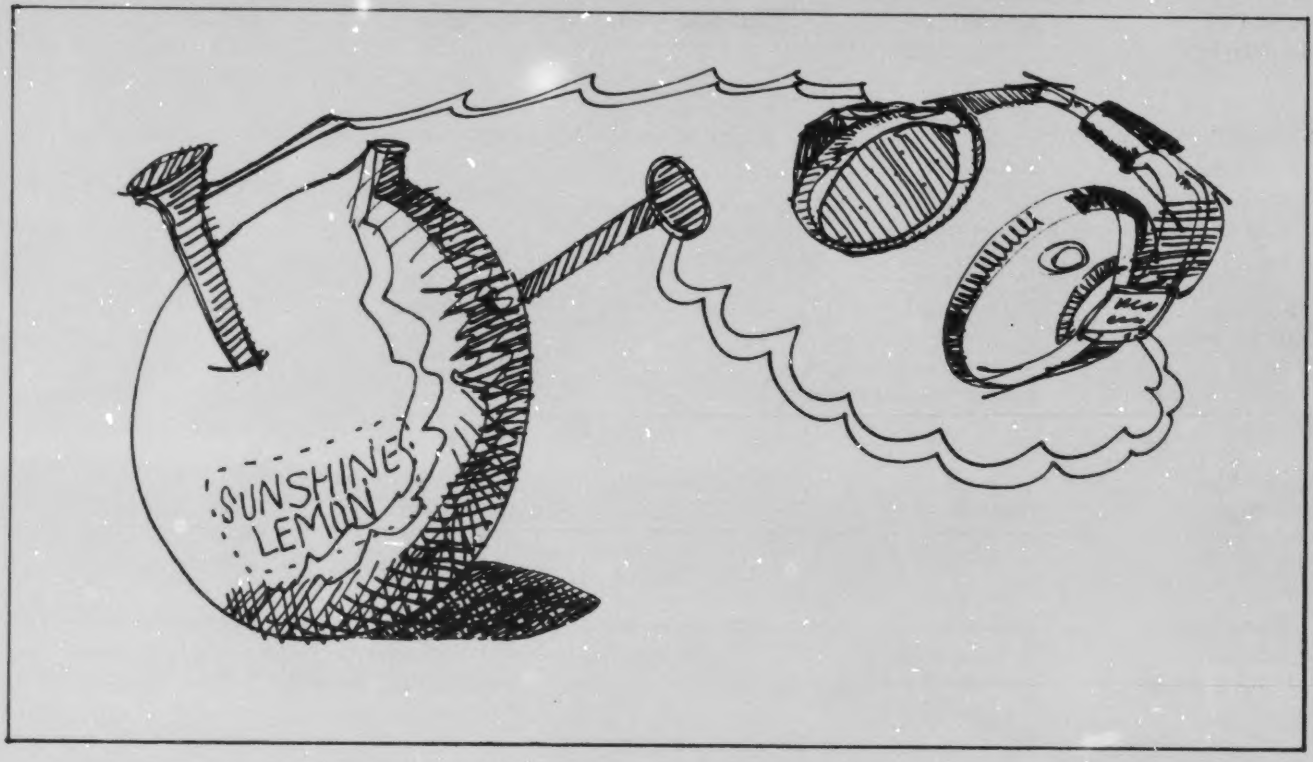
WHAT IT'S ABOUT

Small energy cells are in wide use. But what are energy cells? What are some of their properties and characteristics? In this activity students are provided an opportunity to investigate cells by using simple and readily available materials. An important part of the investigation is that students design and construct their own Weak Electronic Current Detector (WEDC). Activities include:

a. constructing a detector and using it;
b. constructing a wet cell
c. constructing an even simpler wet cell, and considering a
c. variety of wet cells, including storage batteries.

Grade Levels: Junior High — General Science, Physical Science

PILA, ELECTRONS AND GETTING INTO THE FLOW



ENERGY CONTENT AND STUDENT OUTCOMES:
Some Notes On This Unit

Obviously, it is a good thing to think about what students might get from their involvement in this activity. What will they achieve through their involvement in it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Energy Conversion	*Properties of materials	*Observation	*Laboratory safety for myself and others requires acceptance of responsibility.	*Use can be made of energy when change takes place.
Changes: Matter and Energy	*Differences in properties between and within common groups of materials	*Classification	*The need to acquire new skills.	*Chemical changes produce new substances. This change is not easily reversed.
Chemical Change	*Change of materials.	*Measurement.	*Appreciation of the role of science in meeting human needs.	*Electricity is produced when two different metals are joined by placing them in an appropriate liquid.
Influence of electricity on substances	*Cause-effect relationship	*Data Collection	*Appreciation of the work and ideas of some early scientists.	
Chemical production of electricity	*Chemical change results from interaction.	*Prediction.		
	*Properties of materials influence their use.	*Pratical details of handling chemicals and equipment.		
	*More than one variable may be involved in a particular change	*Ability to use equipment to extend the possibility of the human senses.		
	*Energy can be stored.			
	*Energy conversions			
	*Some changes which occur when matter and energy interact.			
	*Construction of a simple electrical measuring device.			

SOME BACKGROUND NOTES

Alessandro Giuseppe Antonio Anastasio Volta was born in 1755 in what is now a popular resort town, Corro, in Lombardy, Italy. Volta was the inventor, in 1800, of the first battery, or **pila**, a combination of chemical cells. He obtained a flow of electric current by using copper and zinc plates—what he called "pairs of metals"—that were separated by moist paper. The order was: copper plate, moist paper, zinc plate, moist paper, copper plate, etc. Volta had previously generated very small charges on two different metals, e.g., copper and zinc, simply by bringing them together. He detected these changes by means of an electroscope.

Volta, in a series of experiments, was also able to show that the metals used could be the same but that they had to be slightly different from each other: clean and bright while the other was oxidized, or hot while the other was cold.

ACTIVITY ONE

Detecting Weak Electric Currents

A Teacher/ing Note:

This activity requires a meter for the detection of weak electric currents. There are several ways to detect weak electrical currents. One is to use a sensitive microammeter. You may not have enough of these for your students. Microammeters are also expensive. Students can make an electric current detector from simple materials.

A set of earphones can also be used to detect the presence of a weak electric current. Their use will not provide a method of determining the strength of an electric current but it can tell students that an electric current is present. When a circuit is completed or broken a click will be heard.

You decide which kind of Weak Electric Current Detector (or galvanometer) you want your students to use: (1) microammeters, or (2) meters built from a project sheet; or (3) meters built from the interaction of kids and materials; (4) earphones; or (5) a #48 bulb (2 volt, 60 ma) in a simple D-cell circuit can also be used but students will have to devise a brightness measure. (Perhaps a photographic meter would work.)

Whatever option you choose you will want to be sure that kids can read their meters accurately, or detect the click (earphones), or have a way of measuring relative brightness (bulb).

Instructions for options (2) and (3) are given below. Of the four detectors, option (3) is the most difficult and time-consuming.

Contruction Instructions

Option (2): Build a Meter From a Project Sheet

Materials List

A compass (pocket size)
Cardboard tube into which the compass fits
Thin copper wire (enameled, #24, 5 meters)
A piece of wood/box to serve as a base and support
Glue, nails, (or screw eyes), tape, tools (side cutters, hammers, soldering gun, etc.)
D cell
Shoebox
Sandpaper, fine
A spare parts box

Diagrams in the activity titled "A Baker's Dozen Hot and Cold Ideas" and step-by-step instructions in the American Museum of Atomic Energy, **Science Activities in Energy** (See Re/Sources) give specific construction details.

Option (3): Build a Meter From the Interaction of Kids and Materials

Materials List

Thin copper wire (enameled, #24) or similiar gauge of plastic-coated wire
Compasses
D cells
Sandpaper, fine
A spare parts box

This approach

- consumes more time than proceeding according to instructions;
- assumes previous student experience with compasses;
- assumes previous student experience with simple circuits;
- assumes that learning by experience and discovery provide richer, fuller and deeper understanding of events than pre-digested approach;
- assumes that you would like to facilitate learning through a helping approach;
- assumes that you are patient and tolerant of student uncertainty and frustration;
- assumes that you are willing to provide the kind of encouragement that will help students focus on the assignment;
- assumes that you are willing to be a co-learner with your students.

Your students may proceed with this construction activity quite quickly if they have had some experience with circuits in earlier grades. Start them off with a question: Does an electric circuit have an effect on a compass?

Provide your kids with the materials and challenge them to construct an electric current detector. You may have to remind them to sand the ends of the enameled wire. Encourage your students to make a table to record the data they collect. Students are being asked to make the most sensitive weak electric current possible: They need to record their findings in such a way that they know which is the best result. Students may have to recheck their findings from time-to-time and some of them will find this frustrating! The records are especially important when students begin considering what combination produces the "best" results.

Some activities and questions you may find useful include:

LEAD-OFF

If students are using unmarked compasses they will need to devise a way to record their findings. How can they do this? Their eyeballs and memory will not be good enough! If students place a piece of paper under their compasses they will be able to record how far the needle moves. Also ask them about repeating each trial. What is accomplished by doing this?

- What would happen to the compass needle if it is laid at the side of a circuit? If the circuit wire is laid over/under the compass? If the compass is included in the circuit?
- What is the relationship between the direction the compass needle is pointing and the wire at the start of the experiment? Does the compass have to be parallel to the circuit?

System Modifications and Improvements

- What would happen if you addeed coils to the circuit? Around the compass? Somewhere else in the circuit? What is the best arrangment, i.e., leads to the greatest needle deflection?
- What is the difference between a 10-coil circuit and a 15-coil? a 25-coil circuit? A 75-coil circuit? In what ways does coil length affect the sensitivity of the device?
- Any differences between a loosely wound coil and tightly wound coils?
- What happens if you place the compass inside a cardboard tube around which you have placed a coil?
- What happens when you add more D-cells?
- What happens when you add D-cells in paralel? In series?

These two require additional materials (2-3" bolts, masking tape, small flashlight bulbs) and some additional knowhow:.

- What happens if you place an electromagnet in the circuit?
- What happens if you place a small bulb in the circuit?

Which combination of modifications and design produces the best results?

Make a Meter

- How would you make a scale for the WECD? (If the compasses you use have numbers on them can they be used as a scale? If the compasses you use do not have a scale how can you make one?)
- How can you "calibrate" the scale?
- If this is to be used as a meter, do you have to use the same scale each time?
- How do you decide when the meter reads zero?
- What is the highest meter value you can use? (Galvanometers do not read higher than 90° or at the point when the compass needle is perpendicular to the coil. This means that the galvanometer can be **too** sensitive to be of use. To be useful, the final position of the needle must lie in the area between 0 and 90° on the scale. It can never be equal to 90°. What should students do to the apparatus when their compass needle reads 90°?
- The activities which follow require the use of a WECD and you and the students will want the meters to be accurate, as well as secure enough, to handle. (By all means encourage students to name them! Give them model numbers!) Ask your inventors to make a holder for it. For this you will need pieces of cardboard, wood, small boxes, tubes, tape, glue, thumbtacks, and some small nails.

Now that you are finished with the WECD,

DE/BRIEF

- What evidence do you have that current flowing in a wire acts like a magnet?
- Speculate on how the WECD works.
- What is the reason that a coil makes the WECD more sensitive than just a straight piece of wire?

ACTIVITY TWO

PART I: WET CELLS

The electric current that kids have used to learn how to use their WECD comes from a battery. These two activities ask students to look more closely at batteries, but from the point-of-view of simple cells.

A Simple Wet Cell — Model I

Materials You Will Need

Carbon rods: These rods may be removed from old flashlight batteries (Score them with a file and break them into two pieces).

> ***An Important Note:***
>
> ***You may have reservations about students dismantling dry cells. Several teachers who used this activity removed the rods themselves before class. If you ask your students to open dry cells urge them to do this carefully. A can opener (pop-bottle type) is a very useful tool. If you do not want your students to open dry cells, pencils/pencil leads, charcoal and other carbon sources may be used in place of the carbon rods taken from old dry cells.***

Metal: **One** of the following: clean zinc or brass or copper or aluminum or lead or magnesium ribbon or iron. (Try to use found materials, e.g., aluminum pie plates/scraps from the metal shop.)

Non-metallic containers: styrofoam cups, jam/baby food jars

Copper wire: bell wire or #24 enameled/plastic coated. Multi-strand plastic/rubber-coated wire is probably best.

Crocodile clips: make connections easy

Sand/emery paper

Solution: household bleach

A WECD (Galvanometer)

Have your students set up the cell and use the WECD to take a reading.

Now extend this investigation by asking students to:

- Improve the performance of this cell. Does the length, thickness of the carbon rod make a difference (use two rods)? Does the area of the metal plate make a difference? What is the effect of distance between the carbon rod and the metal on the performance of the system?
- What is the effect of using different bleaches, e.g., Clorox I, Clorox II, Dry bleaches? Concentrations?
- What would happen if different solutions were used, e.g., sodium chloride, sugar, ammonium chloride?
- What would happen if you hooked up another cell?
- What can be used in place of the carbon rod? Have kids collect metals that they would like to try. Have your students prepare a table/chart which rank-orders the materials they used from most active to least active. Based on your chart which is the most active metal?
- Which pairs of metals give the highest reading?

- Ask "Which pairs of metals give the highest reading?" Be sure students make a chart, e.g., (1) combinations that move the needle; (2) combinations that will not move the needle; (3) reading.

As a wrap-up, ask: 'What are some characteristics of a good battery?"

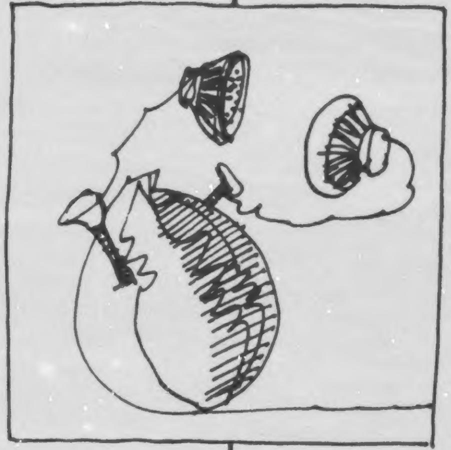
PART II: LEMON-AID

A Simple (R) Wet Cell — Model II

Materials You Will Need

Lemons
Nails/Screws: iron, brass, aluminum
A WECD
Sandpaper or Emery Cloth
Hook-up wire

Ask your students to use these materials (iron, brass nails or screws) to make a cell and to take a measurement. They are to make the best battery that they can with the materials provided. For each step they take have them make a prediction and record their findings, e.g.:



Right | Wrong

If I use an iron and aluminum nail I predict____________ __________
If I use two iron nails/screws I predict____________ __________
If I squeeze the lemon I predict____________ __________

Now initiate an extension of this investigation by asking:

- "I wonder is other fruits, vegetables, juices could also be used as a cell?"
- "Is there such a thing as a salami sandwich cell" or "A stew cell?" or. . .?"
- And finally, "Which of these gives the most current?"

If you have introduced students to bases, acids and the use of pH paper, it will add to the quality of their investigation.

A SAFETY NOTE: It is important that you insist that students do not eat/taste foods in science laboratories.

Encourage the use of predictions and also the recording of data, e.g.:

TRIAL	SOLUTION			CONDUCTOR		WECD
MATERIAL	BASE	ACID	SALTY	YES	NO	READING

When they are finished help them to generalize from their data. What are the regularities in the table? Are there properties that the various cells seem to share in common? What are they? What expectations are there to your generalizations?

A QUESTION AND TWO ANSWERS

1. What does "prove" mean to you? Can you and the class agree on a a definition?
2. Do these experiments prove that metals can be used to produce electricity?
   - ☐ Yes. What convinces you?
   - ☐ No. What would convince you?
3. If you were given a penny, a dime and a piece of blotting paper to separate them, which of the following would make the above the best cell? Rank 1 for best and 4 for worst. Water. Salt solution. Weak acid. Weak base. Why? If there are differences how can you decide who is right? Do you have to do an investigation?
4. If, in the above, a quarter, a 50-cent piece or a silver dollar were substituted, would you have a stronger cell?

RE/SOURCES

Science Activities in Energy. Electrical Energy; Chemical Energy. The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, Tennessee 37830. (Free. These are two in an excellent series of energy activities. You may want the whole set.).

THE HOT DOGS OF PHYSICS

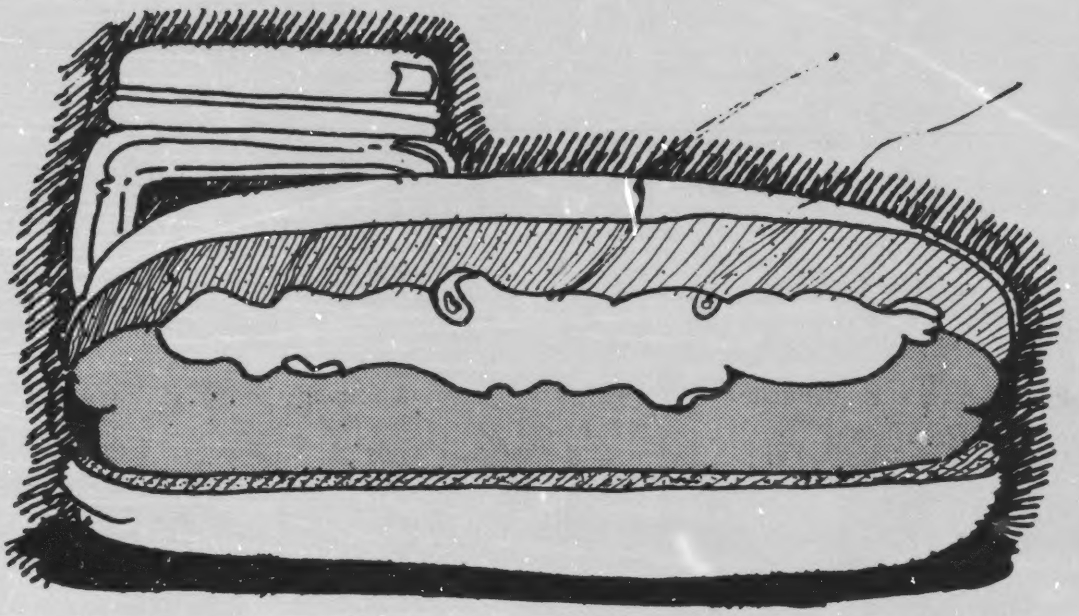
WHAT IT'S ABOUT

In this activity, differential thermal expansion and other energy characteristics are studied using hot dogs. The activity idea was suggested by George Barnes, a physicist at Washington State University (see Re/Sources). This activity may require an understanding of center of mass and center of buoyancy. It is hoped that the approach will bring new physical perspectives to familiar problems.

Students observe and comment upon some dilemmas concerning hot dogs. Why do boiling hot dogs cook for 30 seconds on one side and then roll over and cook on the other side? Do all brands behave the same way? Students develop a scientific model to explain a phenomenon.

Grade Levels: Senior High — Physics

THE HOT DOGS OF PHYSICS



ENERGY CONTENT AND STUDENT OUTCOMES: Some Notes on This Unit

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement it it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

SOME BACKGROUND NOTES

Cooking a hot dog is really a simple operation. . . isn't it? Who would ever watch it? For what reason? What could be learned?

Just think about boiling a hot dog. In order to bring the heat into better contact with the hot dog a liquid is used. The liquid, water, because of its unique properties, prevents the temperature from rising too high. In the process, the nature of the hot dog changes.

However, hot dogs exhibit a curious behavior when they cook at a low boil: they roll over. First they cook on one side, then they roll over and cook on the other side. This back and forth behavior continues until the heat is removed. Energy and physics must be involved.

When a object is placed in a fluid it is buoyed up by a force equal to the weight of the fluid displaced. If the buoyant force is greater than the weight of the object, the object will be lifted to the surface. If the weight of the object is greater than the buoyant force, the object will sink. In water, a log floats at a depth for which its weight just equals the weight of the water displaced. A center of buoyancy can be determined for the log or for any other floating object.

A cooking hot dog (are uncooked hot dogs buoyant?) adds another component to the system. It shows us that the location of the center of gravity (Cg) can affect the stability of a system. When the hot dog is cooked at a low boil two things happen: (1) its center of buoyancy is lowered and (2) its center of gravity is raised. The hot dog rolls.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Energy Changes	*Changes brought about by the interaction of energy and matter.	*Variables -Recognition -Identification -Control	*Developing an interest in approaching problems scientifically.	*The reaction of a system to unbalanced forces —the center of buoyancy and the center of gravity.
Problem Solving	*Changes of state brought about by heating	*Discriminating between observation and inference.	*Willingness to ask questions.	*Energy is either taken in or given out during a change.
*Designing Alternatives				
*Making Projections	*Which kinds of observations are to be looked at in a problem solution.	*Drawing inferences from data		*Models are in the search for an explanation.
*How to Analyze				
*Trying to decide what elements a solution should contain	*Ways to investigate and measure properties.	*Devising experiments to answer questions.		
	*Converting one form of energy to another.	*Hypothesis formation.		
*How to choose among alternatives when the best data are provisional				
	*Models are used to explain phenomena that are not understood completely or observed directly.	*Collaborative skills.		
		*Scientific models.		

ACTIVITY

A Teacher/ing Note: I

Cooking in a laboratory is a safety issue and you have certain minimal responsibilities: (1) **you** know potential hazards; (2) **you** are responsible for the safety of your students; (3) **you** are responsible for reasonable safety measures; and (4) **you** are accountable for the curriculum in the school.

You may not allow cooking in your laboratory. With the cooperation of your students and parents the hot dog cooking can be done at home. If your class is small, you may choose to do the cooking as a demonstration.

If you do cook in your laboratory it has to be done in **one** day. Overnight storage presents opportunities for spoilage. Students should not eat the hot dogs cooked in the laboratory. There are too many opportunities for accidents.

You and your class will have to decide where to get your hot dogs and what kinds to use. Professor Barnes notes that the less expensive brands generally work best.

Present the following dilemma to your students:

Student Dilemma: It's A Hot One!

When hot dogs cook at a low boil, they cook for about thirty seconds on one side, roll over, cook on the other side, roll over again and so forth. What is/are the reason(s) for this curious behavior?

Place students in groups of three and have them generate some hypotheses which explain this behavior and to devise an experiment to test one of them. They are to:

1. List which system variables are relevant to the experiment.
2. Decide how they will measure the turnover rate. What purpose does this measurement serve?
3. Describe the system at the beginning of the experiment.
4. Describe the system near the middle of the experiment.
5. Describe the system at the end of the experiment.
6. Interpret and explain their findings.
7. Develop a model which explains these events based on their knowledge of physics. The model is to be a description or a drawing: it must explain what has been observed; it must be simple and it should be good enough to allow predictions to be made (see below).
8. Report on their observations and their model.

A Brief Word on Models

Models are extremely useful to scientists. They are used to help them cope with puzzles. One way to think about modelling is to think about a model car: (1) there is a one-to-one relationship between most features of a real car and model; (2) in three dimensional space, the model car is in scale. The model car preserves **features** and **relationships.** It is also tangible.

Sometimes scientists create such kinds of model models. More often scientists develop verbal simulation games of analogies. . . the earth as a heat engine (machine). . . the brain as information inputs and outputs regulated by feedback loops (computer). . . the ecosystem as a theatre and play (drama). . . Consider still another "model." A particle physicist is quite likely to initiate a discussion of subatomic particles with "Think of a massless particle." Wow! The analogy is in the form of a koan, a teaching device used by Zen masters.

Models are tentative explanations: an investigator is faced with something that s/he would like to explain. S/he thinks of it **as if** it were something else! The most important thing to remember is that the model may not be a valid or true explanation.

A Word on Experiments

Science is about converting problems into experiments that produce evidence which the investigator can use to prove or invalidate a hypothesis. It would be nice if one experiment would answer a question. This is usually not the case.

In fact, experiments fall within a rather wide range in terms of their explanatory power and what is learned by doing them. Some are simply exploratory probes which provide data on which explanation can be based. Some are methodological in nature. Their purpose is improvement, usually of a technique. Some are designed only to gather facts. "Cookbook" experiments are of this variety as are experiments which seek to understand how a system behaves under a wide variety of conditions. Finally, some experiments are designed to establish the limitations of an explanation: for example, does it work in nature the same way it did in the laboratory?

The question posed of students involves knowing, at least, Archimedes principle and the center of gravity. Putting these two together to explain the behavior of an unstable system will not be an easy task for all young learners. There are also many possibilities for experimental work with the hot dog.

As students describe their models, help them to put the explanation together. This activity is an inquiry and your questions should promote inquiry, e.g.,

1. "Do you agree, Mark, with Alice that this would cause the hot dog to roll over?"
2. "I don't understand that. Please tell me what you mean by. . ."
3. "Would a wooden dowel or a carrot exhibit the same behavior?"
4. "What did you observe when. . .?"
5. "What are the sequence of events?"

As you talk with students, if you have previously discussed information on buoyancy or the center of mass of an object, use these past experiences to help students establish some of the connections between these concepts and the experiment.

NOW THAT

students have gained some understanding of their observations challenge them to the "Great Hot Dog Racing in Boiling Water Contest." The object? To get the hot dog to turn over as fast as possible. One rule: the dog must remain edible. This does NOT violate the no eating policy, it simply eliminates the addition of potentially dangerous chemicals to the water.

You can help by posing questions when they need them. Some suggestions for the hot dog race follow. Students are to answer these in If. . . then. . . statements.

(a) If you add salt to the water what would you predict?____________

____Try it!

(b) If you remove the center of the hot dog what would you predict?

____Try it!

(c) If you add a cover what would you predict?____________________

____Try it!

(d) If you fan the surface of the water what would you predict?______

____Try it!

(e) If an electric fan was used to fan the surface of the water what would you predict?______________________________________

____Try it!

(f) If the dogs are added to already boiling water what would you predict? ____

____Try it!

(g) If dogs and cold water are heated to boiling together what would you predict?___________________________________Try it!

____

(h) If boiling rate (low boil, fast boil) is a factor what do you predict?

____Try it!

FINAL AFTER/WORDS

1. Compare produce package information. Does hot dog composition make a difference?
2. What is the most energy efficient way to boil a dog? You must be able to "prove" it or at least convince us that hypotheses, arguments, experiments designed to test it, and reasoning are sound. A science fair project? (Don't underestimate the lowly dog!)

MORE

1. Compare a variety of brands.
2. Compare high priced versus lower priced brands.
3. Compare all beef and chicken dogs.
4. Compare hot dogs and polish sausage. Would you predict that size (diameter) would have an effect on rolling behavior? What would it be?

RE/SOURCES

Barnes, George B. 1976. Hot Dog Physics. The Physics Teacher 14 (December): 578.

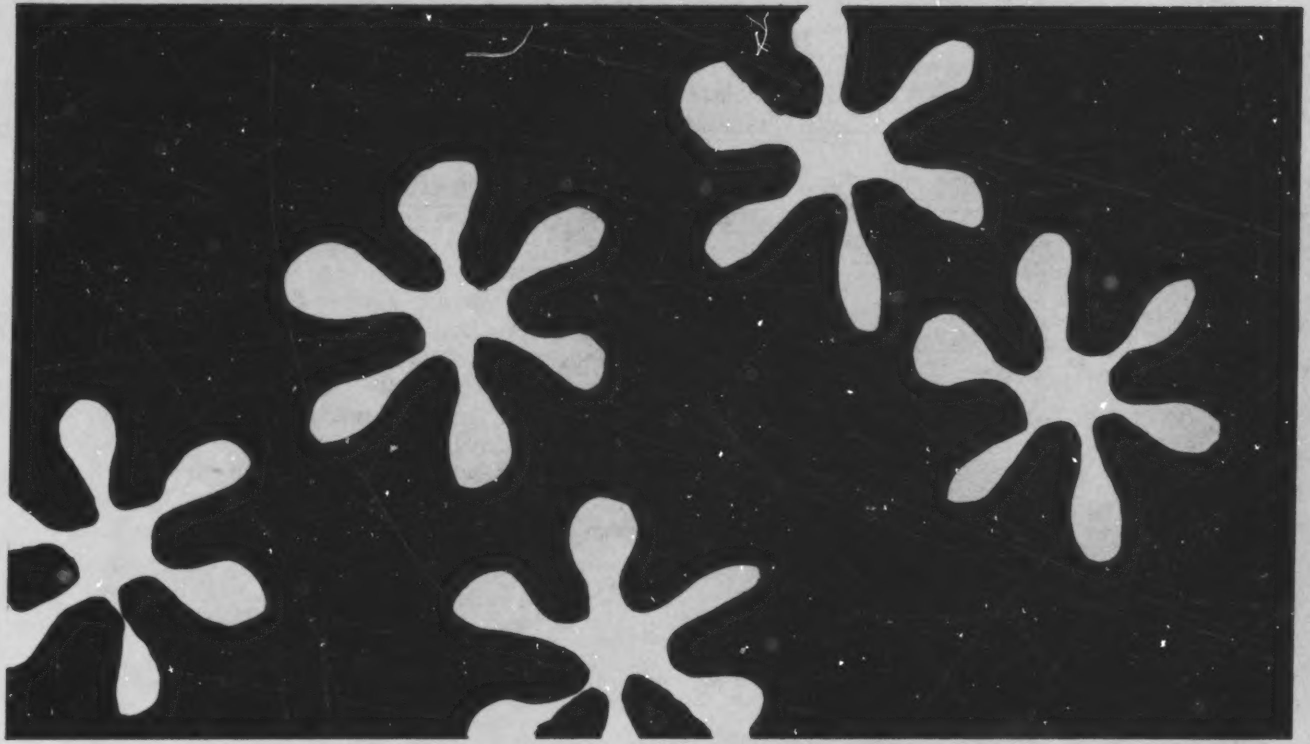
THE MINNESOTA TRANSFER

WHAT IT'S ABOUT

Why do snow, frost, and dew patterns on the roofs of buildings, sidewalks, pavements and on the sides of buildings take the form that they do? What can they tell about the paths of heat leakage and heat transfer? In this hands-on activity students can observe, photograph and interpret thermal patterns revealed by snow, frost and dew.

Grade Levels: Junior-Senior High — Physical Science, Physics, Environmental Studies

THE MINNESOTA TRANSFER



ENERGY CONTENT AND STUDENT OUTCOMES: Some Notes on This Unit

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement it it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

SOME BACK/GROUND NOTES

There is no better or more sensitive way to introduce this activity than through the words of Professor Albert Bartlett. Dr. Bartlett is a physicist at the University of Colorado where he has been named an outstanding teacher by his students. He writes:

> Physics might be characterized as being "analysis based on observation." Observation often implies the need for apparatus with which observations can be made. The apparatus can range in complexity from a meter stick to a meson factory, but clearly the simpler the observing apparatus the larger is the number of students and teachers who can share in the experience of making and interpreting observations. . .,(P)ictures present one of the simplest and most useful types of physical observation that can be made. One need only live in the latitudes where snow and frost occur. The observations are made with your eyes and are recorded with almost any type of camera. Since the phenomena are transient they must be seen and photographed when they appear—but then the pictures can be brought to the classroom where they can provide thoughtful challenges to students.

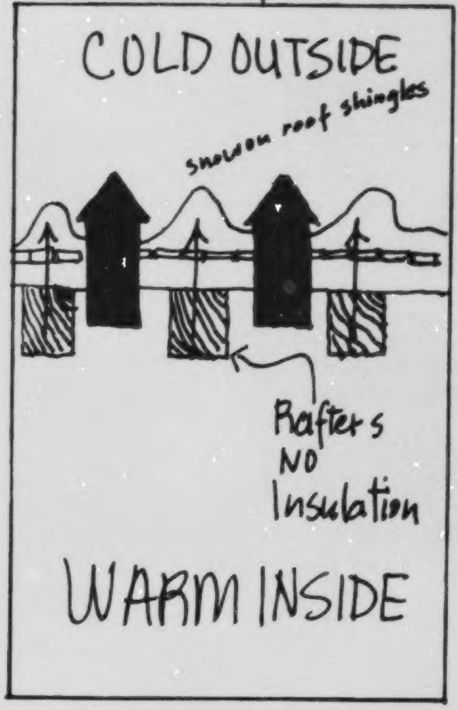
Albert A. Bartlett
"Thermal Patterns in the Snow: Part I
1975. The Physics Teacher 14 (January),
p.14. Copyright 1976, The American
Association of Physics Teachers.
Used with permission.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
*Practical examples of energy conversions	*Changes brought about by the interaction of matter and energy.	*Ability to draw conclusions from observations.	*Willingness to examine evidence critically.	*Developing an inquiring mind and a scientific approach to energy problems.
*Criteria of energy conversions: what to look for	*Conditions which promote changes in nonliving systems.	*Ability to draw diagrams as a means of recording observations.	*Recognition of the need to acquire new skills.	*Constructing ideas of how a subsystem/system probably works.
*Changes and energy	*Ways to investigate and measure energy properties of non-living systems.	*Ability to distinguish observations which are relevant to the understanding of a problem from those which are not.	*Willingness to consider the role of science in everyday life.	
			*More than one variable may be involved in a particular change.	

ACTIVITY

A Teacher/ing Note:



Two learning options are provided in this activity about patterns of heat transfer. The difference between them is that in A, cameras are used and in B, notes and drawings are used to make and record observations.

The activity probably works best in early and late winter when temperatures are at or only a few degrees below freezing. Bitter winter temperatures may mask many of the obvious heat transfer patterns. As students become more observant, acquire practice in reading the landscape, subtle differences in snow and ice distributions will be more easily recognized.

The list of questions about heat transfer provided below requires answers. With your help your students can find the answers.

Why are patterns of snow so different on the roofs of houses?

What are the reasons for the patterns of snow/frost on that parked car or some aspect of that car?

What is the reason for funny patterns of snow on street and sidewalks?

What is the reason that ice is covering the sidewalls of that house?

What is the reason for that curious zig-zag pattern of snow on a roof?

What are the reasons for the pattern of freshly fallen snow observed between the grass, a sidewalk and the street?

Why is that icicle so long?

If an early winter snow falls on a cast concrete wall what accounts for the shape observed on the cap that covers the wall?

What variation in these patterns is observed between early-, mid- and late- winter snows, and how can they be explained?

To make the questions listed above visible, a collection of photographs of such events is necessary or a willingness to take some very detailed notes. What is demanded first of all is an eye for the obvious. Kids are asked to look at something they have never "seen" before and to wonder what caused it and/or what is going on there.

Learning Option A: An Approach With Cameras

Whenever there has been a snow or frost or fog (condensation of water on surfaces is also revealing) students should be ready to go out in the field. It is hoped you can arrange, for at least a few kids, to have an extended lunch period or an afternoon with you in the field looking for and shooting such patterns. Obviously, weekend, as well as before and after school, shooting is encouraged. During trialing, one teacher did all the filming and used the slides s/he collected as the basis for this activity.

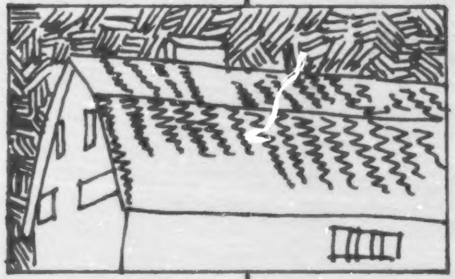
The pictures do not ask for sophisticated cameras or great photographic skills because the photographs are to be used for utilitarian purposes. (Aesthetically pleasant shots that illustrate the physics are obviously not to be discouraged!) What you are most interested in it the distribution of snow and ice (precipitation). You can have kids develop their own film and prints can be made on contact paper.

At first you may want to have kids focus their camera just on roofs: the high, the low, the steep, the less-steep, the flat, the shingled, the tarpapered, the north-facing, the south-facing, roofs on out-buildings, roofs near. . .trees. . .other buildings. . .in the center of town. . .at the edge of town. . . , the old, the new, the middle-aged, the big, the small, the dormored, the. . . But remember! They must have some precipitation on them which reveals a pattern waiting to be explained.

Help students decide on what additional information, if any, they will collect. Some possible categories include: time, temperature, weather conditions, time after snowfall, date, exposure of roof (north-facing, south-facing). Collect only the most relevant information.

A CAUTIONARY NOTE:

Students are **not** to shoot every roof precipitation pattern in their community. They can, by shooting everything in sight, be overwhelmed with the task of analysis. If the class ends up with only a few "curiosities"—maybe no more than a half-dozen—that will be enough. You may even decide they need only two or three different roof pictures: the day of the snow (there may be no obvious pattern); that roof a day later; that roof a few days to a week later (or before the next major snowstorm).



A few pictures saves film, reduces scheduling arrangements, and makes the assignment reasonable. Then let your world enlarge to encourage any and all patterns. Gradually (it may take several years) you will obtain a collection of pictures which covers a wide range of conditions and features. . .all grist for the learning mill!

Learning Option B: An Approach Without Cameras

It is not easy to learn to take accurate notes and drawings. Students have to capture all essential features in one sitting because by tomorrow or next week things will have changed. Encourage detail. Before they leave ask them to learn to take a second look and to compare that look with their notes/drawings. Where is the snow present or absent? Does the valley or depression in the snow run up or across the roof? Is the snow pattern the same over the entire roof or is it different at the edges, over the porch or garage?

After a Light Snow

Example 1;

A student notices a sidewalk with a pattern that interests her. As she draws and takes notes she looks harder. Snow is absent from the edge of the walk near the grass. A ridge of snow lies on the sidewalk adjacent to the curb. There is no snow in the gutter. What is going on?

Example 2:

A light snow has fallen. This time the pattern of the brick sidewalk captures the attention of three students. After examining the drawing, you ask "Why is the snow so slow (or fast) to melt along particular lines?" "What is that blot?" "You have a line indicating that heat is going from the ground to the air. Is that what you saw?"

Student 1: "I got it! I think there was a gum wrapper there. . . it was aluminum. . . a possible explanation is that as the sunlight. . .H-m-m-m."

Student 2: "You're crazy. . .hey, wait a minute, these arrows ought to. . ."

Student 3: "I agree. They need to be changed like this. There has got to be a space. . . an air space or something right there (points to drawing)!"

Student 1: "Yeah, I remember. Hey, I think I remember. . . it's a culvert!"

Student 2: "I live near there, I'll check it tonight."

Student 1: "How will we know it's the same spot?"

Once The Class Has A Collection

Help students to figure out what is going on. Small drawings or diagrams (just part of the roof) — models — may be very helpful. Sometimes a simple cross-section of the entire home may be helpful. Is there evidence of insulation? Does the house have a heated room under at least part of the roof? Ask them to defend their reasoning.

Based on their pictures, notes and drawings, where is the cold air? The warm air? Where is it cold? Where is it warm? Draw arrows to indicate heat flows (If the flows are larger in certain places than they are in other places indicate this with arrow size: "fat" arrow for large flows; "skinny" arrows for smaller flows). Maybe labeling flows will help.

AFTER/WORDS

1. Show the class some pictures (slides) where you know exactly what is going on—the nature of the underlying structures, the thermal properties and conductivities, etc. Have one minute of intense brainstorming on the thermal events. Discuss the list and develop the best possible explanation.
2. Predict what will happen to the pattern a day later. A week later. With the next snow fall (provided certain conditions remain relatively constant). Check it out. How must you modify your predictions? What are the reasons?
3. Have students collect and post "mystery pictures" on a bulletin board. Challenge the class to provide guesses and explanations. You can also participate.

RE/SOURCES

Bartlett, Albert A. 1976. Thermal patterns in the snow., Parts I, II. The Physics Teacher. Volume 14: (January) 14-18; (February) 86-90.

Bartlett, Albert A. 1978. A thermal-gravitational pattern in the snow. The Physics Teacher. Volume 16 (September): 642.

Bartlett, Albert A. 1979. A thermal pattern in the snow. The Physics Teacher. Volume 17 (March): 193.

Fichen, George W., Jr. 1976. Physics at Home and in the Backyard. The Physics Teacher. Volume 14 (May): 282-286.

Grange, Howard L. and Lewis T. Hendricks. 1976. Roof-Snow Behavior and Ice-Dam Retention in Residential Housing. Extension Bulletin 399. Agriculture Extension.
Service, Bulletin Room, Coffee Hall, University of Minnesota, St. Paul, MN 55108. (Single copies free)

Petman, Donald S. (Compiler). 1975. Fact Sheet: Is Your Home Properly Insulated? Ventilated? Agriculture Extension Service, Bulletin Room, Coffee Hall, University of Minnesota, St. Paul, MN 55108 (Single copies free)

Walker, Jearl. 1975. The Flying Circus of Physics. John Wiley and Sons, Inc., New York ($8.50).

A SOLAR COLLECTION AGENCY

WHAT IT'S ABOUT

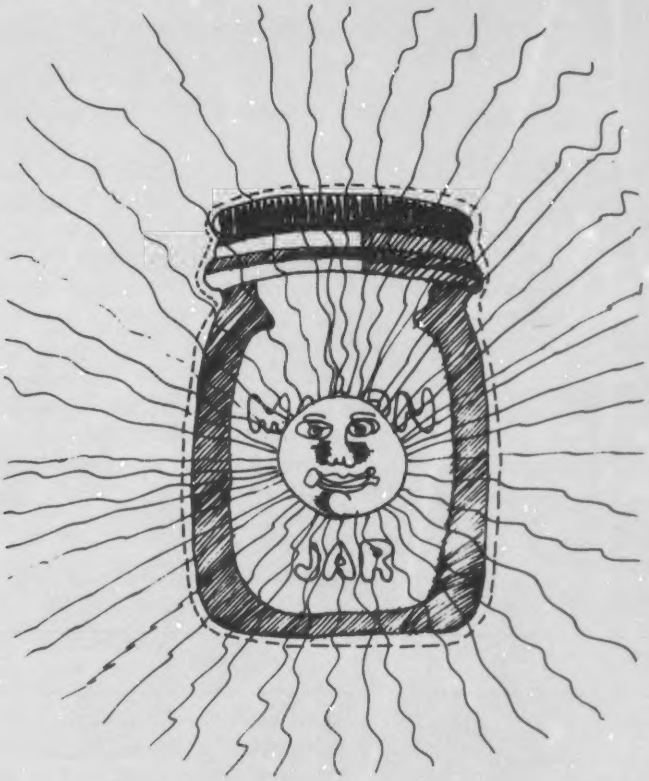
The approach taken in this material is to emphasize science at the expense of community, regional, national and global solar energy problem solving. In fact, students do not do the obvious: they do not build a task-oriented, solar collector, e.g., a solar cooker, of any kind. The sun is used to make some points about energy conversion, transfer and storage.

The problems which follow involve meaningful problem-solving rather than rote discovery or guided inquiry learning. They are not type problems and do not have predetermined answers. The packet includes a questionnaire for students and activities about:

a. Liquid Collectors (Design investigations that prove students are able to capture the sun's energy.).
b. Flat Heat Collectors (Controlling Variables Related to Absorption).
c. Flat Heat and Liquid Collectors (Inventing a Better Collector).

Grade Levels: Junior-Senior High — Life Science, Earth Science, Physical Science, Environmental Studies, Physics

A SOLAR COLLECTION AGENCY



ENERGY CONTENT AND STUDENT OUTCOMES: Some Notes On This Unit

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement it it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

SOME BACKGROUND NOTES

Natural systems do a lot of free work everyday. In his statement for "Sun Day" 1978, U.S. Secretary of the Interior Cecil Andrus said: "In just 75 revolutions of Earth around its star, we have managed to burn up a billion years of buried light from that star, our sun. As the fossil fuel bank account runs out, we again recognize the solar blessing that pours down daily and runs the life support systems of the earth." Most of us forget the fact that life support systems of the Earth run entirely on solar power. These systems presently comprise more than one-third of the total energy that drives human society.

Now that we have noticed what the sun can do for us, we tend to rush in with a bunch of gadgets (all of which depend for their manufacture on fossil fuel) that will "improve" on what the sun is already doing. In the long run, attention will have to be increasingly focused on the "free" work the sun has always done, and continues to do. We will have to learn about the natural systems powered by the sun—how they work and where they have grown and swollen from massive infusions of non-renewable fossil fuels. We will have to learn how to use these "free public service functions" of nature to our advantage—in ways from which we benefit and the functions are not interfered with, as many are at present. Wouldn't it be nice to plug as much of our "wastes" as possible into the circular systems of nature so that they could be used as building materials for another round?

But this is still down the road. There is much that can be done, but only by learning and planning and allocating resources. The ideas in this series of activities fit in the "Learning" category. They owe their origin to Steve Baer, a proven and innovative solar experimenter, who is the founder of Zomeworks Corporation. He wrote:

> The events that take place with air and water at different temperatures are fascinating to observe. I would recommend getting a clear bottle—quart beer bottles are very nice—filling it almost full of water and admiring it. When you touch a bottle filled with water you become aware of its insistence on maintaining its own temperature. You feel a calm authority as a cool bottle steadily takes heat from your hand or a warm bottle supplies it with heat. Water is able to hold as much heat as an equal volume of metal and twice as much as equal volumes of stone or masonry. It as a very stable disposition.
>
> Picking up an old bottle from the trash, cleaning it, filling it with water, and playing with it is exciting in another way. It is evidence of the beauty and inexpensiveness of machine-made products. Spilled water is such a completely different substance. Containers are true marvels.

Steve Baer
Sunspots, 1975, p. 32
Used with permission

SCA 3

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Devising experiments to answer questions about energy	*That the sun's energy can be captured, stored and transferred.	*Devising and contructing simple physical models for investigation.	*Willingness and the gaining of confidence to experiment with the energy world.	*Energy is either taken in or given out during a change.
	*Specific informations of an energy form encountered in everyday life.	*Experimental design.	*Enjoyment in developing methods for solving problems and/or testing ideas.	*It is only when change takes place that use can be made of energy.
	*Some changes brought about by the interaction of matter and energy.	*Ways to investigate and measure properties of design changes	*Science and prediction go together.	*Energy change is important in meeting human needs.
	*What I do to a system makes a difference in how the parts act.	*Ability to select the communication form most appropriate to the information being recorded.	*Appreciation of the relationships of parts and wholes.	*The ultimate source of energy is the sun.
	*Characteristics of good and bad solar collectors.	*Ability to use graphs to record.		*Appreciation of the implications of changing the scale: as scale changes, relationships change.
		*Ability to deduce information from graphs.		

It's Your Classroom

A Teacher/ing Note:

It is not the intention of these materials to create a chaotic teaching situation for you although we are aware of the complexities created by these project suggestions. Obviously rates of progress will vary, some kids will want/need more help than others. "Success" rates will also vary.

Treat, if you can, the activities as presented without a lot of explanation but with a lot of enthusiastic fanfare! Your role is to provide "fetching" questions, starters, to encourage alternative solutions to the problem dilemmas presented and to practice helpful non-judgment.

There are not necessarily "correct" answers but some solutions will be better than others. Students should be made to understand that they are in this together. The teacher or the class "whizzes" do not have the answer. Instead, you and your students are engaged in a search for answers.

The materials emphasize "hands-on" experiences and very frankly, the kind of "messing" that is a real part of scientific inquiry. A post-laboratory experience is crucial! (1) to help kids synthesize and re-examine their work, and (2) to provide some closure and help students analyze what they did.

As you complete activities you can ask

- individuals/teams to report on what they have found;
- what the results mean to them;
- what some of the differences are;
- why there are differences;
- how to improve;
- the ideas of "success" and "failure";
- what kids/teams learned;
- what are some of the reasons things always don't work the way you thought they would.
- Review facts: this serves to let everyone find out what is known about the situation; to locate areas of agreement and disagreement; and to help everyone consider all the facts;
- Infer relationships: ask students to try to interpret, state relationships and evaluate ideas. It is important not to ridicule any ideas but to create an atmosphere of respect for all possibilities.
- Engage in problem-solving discussion as small groups work: some of the activities require solutions for new situations. Help students to build on ideas about the procedure to follow and sequence of steps in the work.

Materials and apparatus have been kept simple. While many skills are required, the most immediate is the ability to read a thermometer. The other skills center around creative problem-solving. Encourage students with comments such as "Have you thought of. . .", "I wonder whether. . .", "If we placed that here would it. . .?"

These activities expose your kids to very personal elements, namely, the personal elements that are present in every task that they try in school: frustration, boredom, anxiety, fear of failure, lack of confidence, over-confidence, etc. Kids can be easily disabled by "wise" comments and hints of uncertainties about their work. It is important that as the work progresses, thoughts and feelings about the work are shared, confusions revealed and clarified. Listen to your students, draw them out, help them to share information and to pursue their solutions.

Teacher availability, interest and a concern for students as people and science learners is a must but you must also help them make significant decisions. You probably don't want to function as either a giver of constant, detailed instructions or as an encyclopedia. You will probably have to actively seek-out some kids in your class so that they have a chance to take stock of their work (and themselves).

ACTIVITIES:

Number 1: A Teacher Activity

All of the activities require sunlight; the more direct the better! (you can, of course, use incandescent "sun" lamps.)

The purpose of this activity is to introduce the student activities (2-7) which follow.

Materials You Will Need Include:

Clear flat dishes/containers/petri plates
Thermometer
Colored Construction Papers
Insulating materials: e.g. styrofoam, newspaper, blueboard, fiberglass, cardboard
Sand
Stones
Mud.

Before your class meets, place equal amounts of water in clear flat dishes and set them where they are in the direct rays of the sun. Each of the dishes should differ by one variable, e.g., uninsulated from surface heat; insulated from surface heat; various colors of construction paper beneath; clear water, muddy water; soapy water; and/stone bottom, etc. You might even include one with an unequal quantity of water!

Have your students make some predictions about each of them, e.g.:

- which one will get warmest first/last
- which one is the warmest now
- which one will stay warmest the longest
- which one will cool most quickly
- which one has stored the most energy?

Tally the responses so that they are visible to the entire class. Rank order the listing. Ask students to defend their responses. Focus specifically on the variables which kids think influence the temperature differences in the containers. Take the temperatures and record them with the tally responses. Compare these with predicted sequence. Do they agree? If there are some surprises, discuss these with the class.

While the answer is obvious (Everyone "knows"), ask them where the heat comes from. Is it light, or heat, or light and heat, from sunlight? Does heat from the sun reach the Earth? Does heat travel as far as light?

If students don't comment on the plates insulated from surface heat gain be sure to ask them about whether these plates help, in any way, to answer this question. Can heat travel as far as light?

Can they think of some ways which prove the answers to this question? This could be an assignment. They are to devise an experiment which answers the question, at least indirectly, and to your and their satisfaction, that light travels farther than heat.

Close the activity by asking students some properties of a good solar heat collector.

Number 2: Student Activity — Liquid Collectors

In this activity a switch from flat dishes to other kinds of containers is made. If you prefer, continue to make use of the flat dishes. The activity is so similar to the class demonstration that you may want to omit it but the next activity relies on a comparison and requires this step.

Some Materials You Will Need Include:

Assorted containers
- glass
- plastic
- cans
- bottle caps/corks
- hose materials: rubber lab, lawn hose, either plastic or rubber

Thermometers
Metal tubing: copper, radiator.

AS/SIGN/MENT: From the equipment/supplies provided, design an investigation which proves that you were able to capture the sun's energy.

1. Describe the procedure you used.
2. List the materials.
3. Record your findings in a way that shows you were able to complete the task.

Number 3: Student Activity - Liquid Collectors

Some Materials You Will Need:

Container used in #2
Assorted paper, cardboard pieces
Crayons
Flat black paints/tempera paints
Insulation materials.

AS/SIGN/MENT: Make the collector you designed capture energy more effectively.

1. Describe what you do.
2. Record your findings.
3. How do you know how successful you were?
4. Some questions:
   a. What variables speed up energy transfer? Slow it down?
   b. What variables influence the amount of energy transfer?
   c. From the choices below, which is the best thing to do first in an experiment:
      a) Collect the equipment?
      b) Carefully state your purposes?
      c) Read a science book on the subject?
      d) Determine the facts?
      e) Make a guess?
      f) None of the above. The first thing to do is:____________
      ____
   d. Describe what happens to the light energy that strikes your solar collector.

Number 4: Student Activity — Liquid Collectors

(It is possible that this suggestion will elicit some boredom and cries of "Oh, no! Not again!" For that reason you may want to skip it. However, be dramatic! This is to be their ultimate design.)

Some Materials You Will Need:

Same as #2

AS/SIGN/MENT: What can you do to make your solar collector even better so that it will capture even more energy than before? You must be able to convince your teacher/classmates that it is a better collector than your previous one.

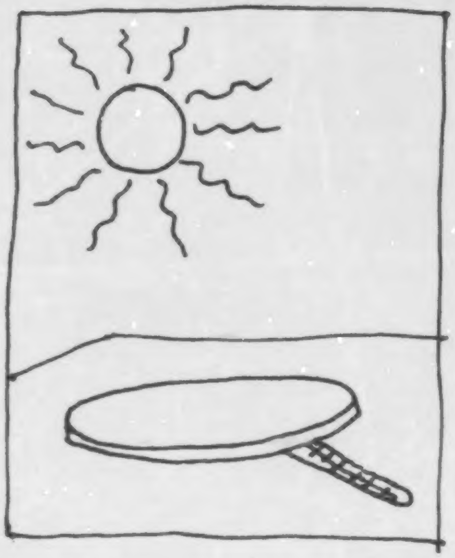
1. Record all pertinent observations.
2. State your findings and what they mean to you.
3. A Question:
   What are the reasons that this design works better?

Number 5: Student Activity — Flat Head Collector

In this activity students are presented with a new heat collector: A flat metal surface. The purpose of the activity is to extend the idea that the sun's energy can be captured by a variety of methods and also to suggest some problems to be solved in its capture.

Some Materials You Will Need:

Assorted can lids
Aluminum foil, 2 cm X 4 cm
Thermometers
Cardboard — white, other
Colored paper
Flat black paint, crayons, tempera paint, Scissors
Insulating material
Tape
Clothespins: snap type or clamps.



AS/SIGN/MENTS:

5a. **If** I place a thermometer on a flat surface underneath a can lid/foil in the direct light of the sun **then** I predict____________

____

Now, try it.
What happened?
Does your observation agree with your prediction?
Why/Why not?
What is increasing the temperature of the metal surface?
How can you be sure that is it the sun and not some other heat source?
To be sure that it is sunlight alone and not the addition of some other energy source that is heating the can lid/foil I would do the following:

____

Do it!
What happened?
Does this really prove that it was sunlight that is heating the metal and not something else?
Why?

5b. **If** I hold my thermometer behind the can lid/foil while the lid/foil is vertical to the direct light of the sun **then** I predict____

____

Do it!
Record your results.
My observations agree/do not agree with my predictions.

5c. Which is the better heat collector? (Circle one and answer the question below.)

a) flat plate in horizontal position
b) flat plate in vertical position
c) they are both the same

These are the reasons:________________________________

____

5d. Are you sure that your thermometer measurements are accurate? Make your thermometer an even better temperature recorder.

(Teacher note: The idea here is that a lot of heat may be lost at the interface of the bulb and the metal unless the bulb-metal interface is made as tight as possible. If a layer of foil (or other material) was placed behind the thermometer to create a metal-thermometer-foil-sandwich, would the temperature be more accurate? If the foil was "pinched" around the thermometer would the reading be even more or less accurate?)

5e. Teacher Note: There are many ways to do the following assignment. The obvious question is whether a dark/dull surface is a better energy absorber than a bright/light one but the as/sign/ment is more open and, perhaps, less leading than this. Some students will need help.

What can you do to make the metal surface you chose to work with in 5a a better energy collector (and prove it)? You may use either a vertical or horizontal positioned collector.

Do it!
Describe what you did.
Record your results.
How successful were you?
Compare your results with your previous experiment and record the differences in a table/graph.
In this experiment which of the following are you doing:
( ) Increasing the rate of change of temperature?
( ) Increasing the temperature change?
( ) Increasing the length of time that the flat plate collector stays warm?
How do you know for sure?

5f. A dark/dull surface is a better energy absorber than a light/bright one. By the way, do you agree with that?

☐ Yes
☐ No

What evidence do you have that it is true?
Does it make a difference whether the side facing directly toward sunlight or the side facing away from direct sunlight is the blackened surface?
Make a prediction and check it out.
Would your heat collector be even better if both sides were blackened?
Make a prediction and check it out.

Number 6: Student Activity — A Flat Head Collector

AS/SIGN/MENT:

6a. **If** I increase the surface size of the heat collector **then** I predict that the temperature will__________________(increase, decrease, stay the same).

Do it!

Did you do it?

How sure are you that you did it:

a) Very Sure?
b) Sure?
c) Unsure?
d) Not Very Sure?

Why are you so sure, unsure, not very sure________________
(answer one)

6b. **If** I double the size of the heat collector **then** I predict that the temperature will______________________________

6c. **If** I double the size of the heat collector **then** I predict that the next point on my graph will be__________________________

Try it.

Is there a relationship between size and temperature?

What is it?

What are some reasons a larger surface captures more energy from the sun?

Number 7: Student Activity — Flat Heat and Liquid Collectors

7a. You have learned quite a bit about the nature of heat collectors. A dark/dull surface is a better energy absorber than a light/shiny surface. A larger surface is a better energy absorber than a smaller one.

As you have observed, there is a major problem with a dark surfaced heat collector: heat loss occurs nearly as fast as heat gain. High temperatures mean high heat losses.

Some Materials You Will Need:

Aluminum pie plates/Styrofoam cups
Cardboard
Plastic wrap/Glass
Paint: flat black, tempera
Crayons
Thermometers

AS/SIGN/MENT: If I place a pane of glass or plastic wrap over the front of my heat collector then I predict that heat is **less likely, more likely** to escape.
(circle one)

Describe the procedure you used.
What do you measure?
How do you measure it?
How do you report the data? Table/Graph?
What can you infer from your measurements?

7b. Improve your heat collector.

Make a prediction.
Describe the procedure.
What do you measure?
How do you measure it?
How do you report the data? Table/Graph?
What can you infer from your measurements?
How successful were you?

7c. This is an invention activity. Your students will need the materials used in other activities as well as additional materials which they will have to find.

According to solar engineers, a heat collector is a panel through which a liquid or gas flows to pick up the heat. Such panels are called flat plate collectors. They combine good heat transfer, heat absorption and heat retaining qualities. Based on principles you have learned from these activities you are to devise a way to transfer the energy gained by a flat metal plate to a liquid heat absorber and retainer. You are designing a solar collector which will collect as much heat as possible with minimum losses.

It would be very useful for you to make some tentative hypotheses—some predictions—to help you think about ways to do this. Two examples—which may or may not work—follow:

- If I painted or blackened the bottom of a water-filled aluminum pie plate, placed the can in direct sunlight I predict

  ____

  ____

- If I laid a water filled hose on a flat black plate in a glass/plastic wrap covered box in full sunlight I predict

  ____

Once you make a prediction you must:
Describe the procedure.
Decide what to measure.
Decide how to measure it.
Decide how to report your observations.
Make an inference, based on your measurements.
Describe how successful you were.

AFTER/WORDS

1. Distribute the drawings in Appendix A and ask kids to answer these questions:
   a. List all variables which influence collector performance.
   b. Predict which collector is better.
   c. Explain the reasons for their choices.

   Answers:
   A. 2a is better than 1a because the tubes are more frequent and the heat does not have so far to travel to reach the liquid.
   B. 2b is better than 1b because the tubes are placed in front, directly in the sun, and therefore some of the heat doesn't take a detour through the plate.
   C. If a certain area is being exposed to the sun, it is best to make the side insulation thin rather than thick since the area is more useful in picking up heat itself rather than protecting the loss of heat picked up somewhere else. 1c is better than 2c.
2. In a solar flat plate collector, the sun warms the plate, the plate warms the tubes, the tubes warm the liquid.
   Rank these from coldest to hottest.
   Defend your answer.
3. Ask kids to respond to the Student Questionnaire, summarize the data and discuss.
4. Fill out the Teacher Questionnaire and describe your reactions to the class.

5. A pane of glass over the front of a solar hear collector cuts down by about 10% the amount of energy that reaches the collecting surface. What are some reasons that it is used?

STUDENT (QUEST)IONNAIRE

1.	I like to work in small groups.	SA	A	D	SD
2.	I prefer to work by myself.	SA	A	D	SD
3.	There is usually more than one way to solve a science problem.	SA	A	D	SD
4.	I like to take measurements.	SA	A	D	SD
5.	I like to record measurements.	SA	A	D	SD
6.	I like to try things out for myself rather than having a lecture or seeing a movie about them.	SA	A	D	SD
7.	I don't mind telling someone my idea for solving a problem no matter how crazy it sounds.	SA	A	D	SD
8.	I like to find better ways to do things.	SA	A	D	SD
9.	This work was: fun	SA	A	D	SD
	hard	SA	A	D	SD
	interesting	SA	A	D	SD
	made me think	SA	A	D	SD
	helped me to think.	SA	A	D	SD
10.	I learned some important things about energy.	SA	A	D	SD

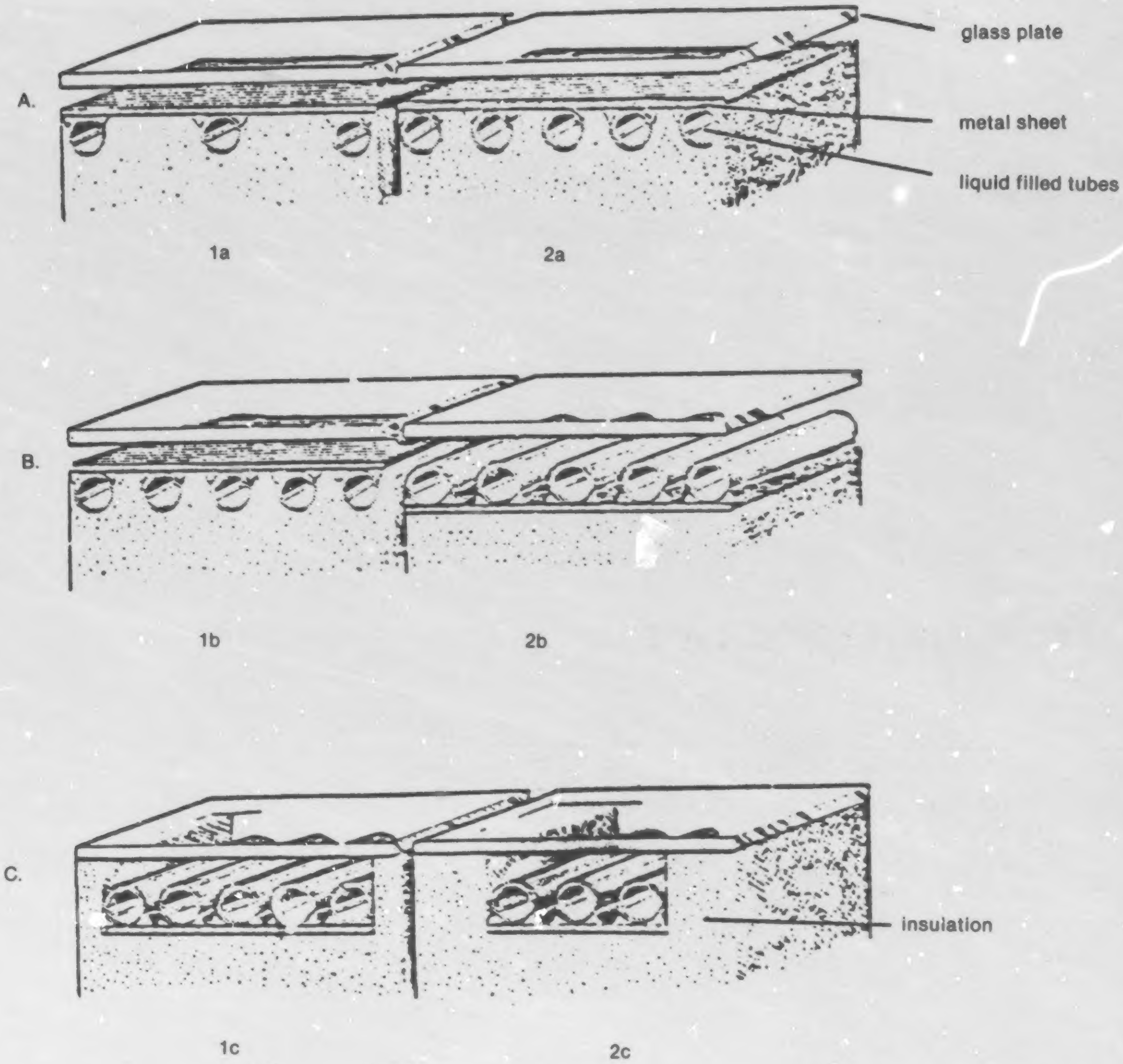
TEACHER (QUEST)IONNAIRE

		Agree	Disagree
1.	These activities allowed students to make significant decisions.	( )	( )
2.	These activities provided students a rich variety of alternatives.	( )	( )
3.	The learning environment that these activities create/require is one that I like.	( )	( )
4.	I think students had an opportunity to learn something significant about energy.	( )	( )
5.	I think students learned something about energy. In my opinion students learned the following about energy:____ ________________________________	( )	( )
6.	I am satisfied with the outcomes.	( )	( )
7.	The "experimenting" heped kids find out things for themselves.	( )	( )

APPENDIX A

A Final Exam

Some Collector Comparisons


glass plate
metal sheet
liquid filled tubes
A.
1a
2a
B.
1b
2b
C.
insulation
1c
2c

Modified from **Sunspots** by Steve Baer, p.57. Used with permission.

RE/SOURCES

Baer, Steve. 1975. Sunspots. Zomeworks Corporation, P.O. Box 712, Albuquerque, NM 87103 ($4.00).

Prenis, John (Ed.). 1975. Energybook #1: Natural Sources and Backyard Applications. Running Press, 38 South Nineteenth Street, Philadelphia, PA 19103 ($4.00 plus $0.25 postage).

WITH HEAT YOU NEVER HAVE TO REPEAT DIRECTIONS

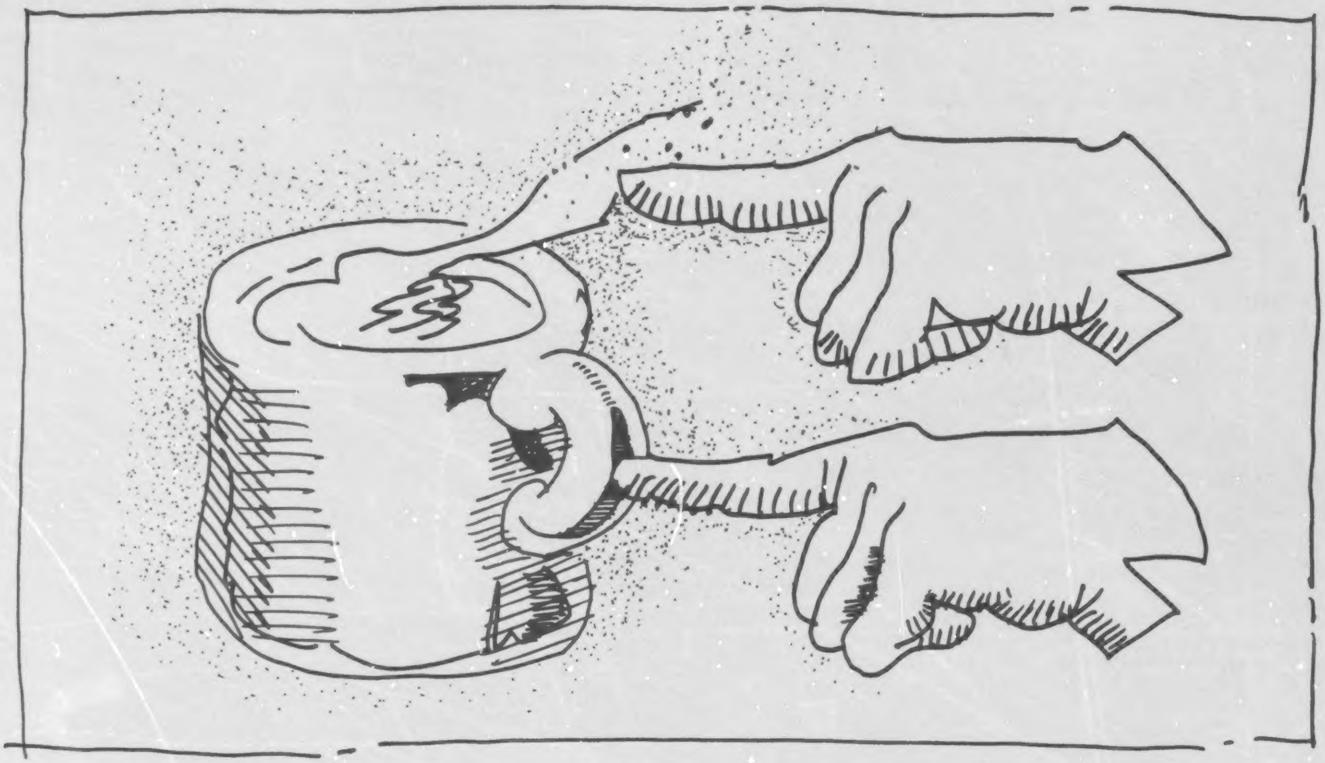
WHAT IT'S ABOUT

In this activity students become familiar with some basic characteristics of heat transfer. In addition, the experiences provide an opportunity for students to learn that the heat gained or lost by matter depends upon three things: the amount of material, the kind of material, and the temperature change or difference. Three well-known demonstrations/experiments on conduction, convection and radiation are also included. These activities distinguish between experiments and demonstrations, with the latter activities concerned with a phenomenon and the former with finding an answer to a posed question. The demonstrations and activities are:

a. Demonstration #1: Conduction— as heat is conducted along a rod, wax melts, drops paper clips. Good versus poor conductors.
b. Demonstration #2: Convection/Conduction—considering the effects of convection and conduction in a system.
c. Demonstration #3: Radiation—effects of sunlight on various surfaces: black, white, etc.
d. Activity: Air Bags—students are asked to make predictions about which system will gain/lose heat.
e. Activity: Sensible Office Clothing—designing an experiment that "proves" that certain kinds of clothing are cooler than others.
f. Activity: A Cold Feeling—the effect of windows on room temperatures and the feeling of cold.

Grade Level: Junior High — Earth Science, Physical Science, Weather

WITH HEAT YOU NEVER HAVE TO REPEAT DIRECTIONS

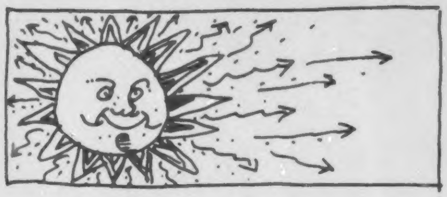


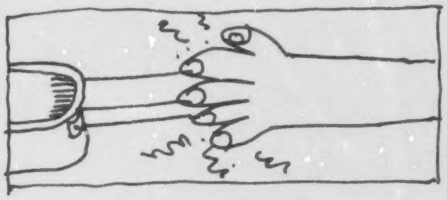
ENERGY CONTENT AND STUDENT OUTCOMES: SOME NOTES ON THIS UNIT:

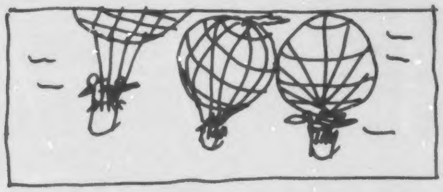
Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement in it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

SOME BACK/GROUND NOTES

It is well known that energy can be transferred from one place to another. Heat transfer occurs by three basic processes: conduction, convection and radiation. In some respects, convection may be thought of as a form of conduction.







RADIATION : The transfer of heat from an object. All heated bodies emit thermal electromagnetic radiation. It includes the direct acquisition of heat from the sun as ultra-violet, visible and infra-red energy, as well as exhanges of heat radiated to and from the environment.

CONDUCTION : The transfer of heat through a solid. It occurs without displacement of material. The rate of conduction is a function of temperature gradient. The shape of the body losing heat and the structure of the surroundings greatly influence conduction rates.

CONVECTION : The transfer of heat in materials that can flow. When a heated object is in contact with a gas or liquid having a lower temperature (or the reverse), heat is transferred between the object and the gas or liquid. In the case of a gas, the change in density is large and the positive (or negative) buoyancy of the gas adjacent to the heated (or cooled) surface causes it to move. A new quantity of gas then comes into contact with the surface and the process continues. In liquids, the change in density is less and the process is slower. A good example of convection is the increase in cooling (or heating) produced by the wind.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Examples of energy conversions	*Common energy conversions.	*Identification and control of variables	*Enjoyment in developing methods for solving problems.	*Developing an inquiring mind and a scientific approach to problems.
Devising experiments to answer questions	*Conduction.	*Hypothesis formation.	*Willingness to examine evidence critically.	*"Models" can be used to explain what humans observe but cannot directly experience. Models can be physical or mental representations of phenomena. They can explain observations.
	*Convection	*Develop an appropriate sequence for a laboratory investigation.	*Willingness to consider the role of science in everyday life.	
	*Radiation	*Experimental desings.	*Commitment to the idea of physical cause and effect.	
	*Properties of matter can be explored by its particulate nature.	Collecting and analyzing data.		
		*Interpreting results and drawing conclusions.		

For/On Teaching The Demonstrations

A Note To The Teacher

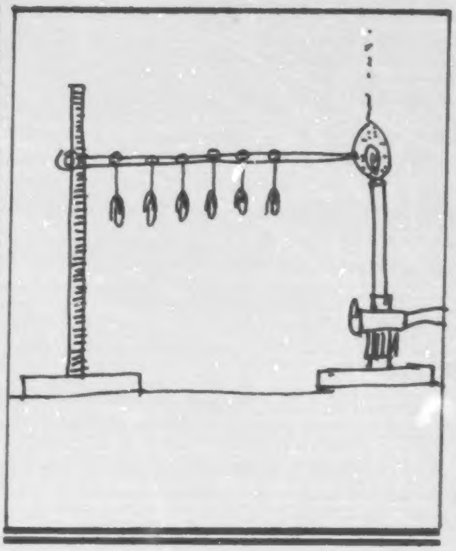
Three of the most commonly used demonstrations are included for your consideration. You can use them as demonstrations, independent student projects or class assignments.

Each demonstration begins with a listing of the materials and equipment needed. The procedure is then explained. There are examples of questions which you might ask which introduces/clarifies the concept or to continue to develop and complete the demonstration.

DEMONSTRATIONS

Demonstration #1: Conduction

Oldies But Goodies



You Will Need:

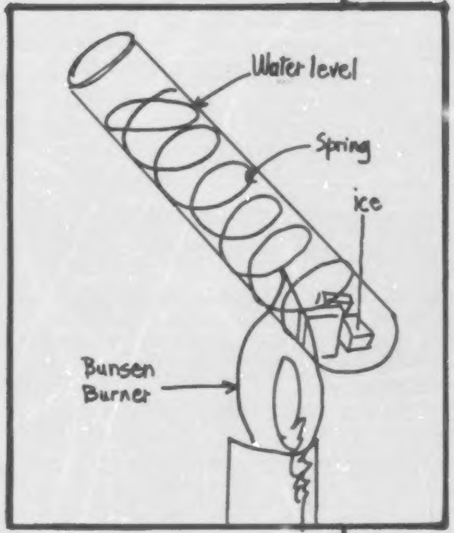
Heat source: Bunsen Burner
Rods: glass, metal, 10-25 cm long, less than 1 cm diameter
Ringstands
Clamps
Paper clips, thread, wax chips.

Place wax, suspend paper clips from thread at intervals on rod. Suspend wax-thread-paper clip combination in air an equal distance away. Make decisions about the information you are going to collect. Heat end of rod.

1. What variables have an influence on the rate of heat transfer in these systems:
   - rod thickness?
   - rod composition?
   - rod and candle flame position?
   - other?

   How would you find out?
2. If you know the time the first clip falls from the rod can you then predict the time the other clips will fall? Why/Why not? How accurate can you be? How could you become more accurate?
3. What happens to the air-suspended, wax-threaded-paper clip? What does this tell you about the thermal properties of air?
4. Rank order the materials tested from good to bad conductor.
5. If twice as much heat was used, predict what would happen.
6. If the thickness of the metal rod was doubled predict what would happen. Is there any relationship between mass and temperature change?

Oldies But Goodies Demonstration #2: Conduction/Convection



You Will Need:

Heat Source: Bunsen Burner
Test tube: large (20 x 75 mm)
Test tube clamp
Metal spring to fit in test tube or heavy copper wire
Ice
Boiling Chips
Thermometer
Eye Protective Device: safety goggles.

Put crushed ice in bottom of test tube. Place metal spring and water in tube. A twist placed in a copper wire will also work to hold the ice in place. Incline tube and heat the water in the top of the tube until it boils. You may want to take some temperature measurements.

Is water a good or bad heat conductor?

- What could you add to this system to make water a better heat conductor?
- Make some predictions about changes in this system in the next 5, 10, and 15 minutes. Is cold coming in? Is heat going out?

Place a small pinch of boiling chips in the bottom of a test tube and gently fill the test tube with cold water within 2-3 cm of the top, incline and heat it near the bottom. Gently warm the test tube while moving it **slowly** back and forth in the frame. Observe the water closely.

- How does heat seem to be transferred in water?

Oldies But Goodies Demonstration #3: Radiation

You Will Need:

Heat Source: A sunny window, Electric resistance heater
Tin cans
Paint: black, white, flat and enamel
Cardboard
Thermometer
Water

Fill cans with water at the same temperature. Cover each can.

Place cans in heat source. Record temperature every 5 minutes. Record the data.

- What are the relevant variables in this system?
- What tentative conclusions can you reach about probable relationships among the variables?
- What could you do to make the collector a more efficient system? Try these and see whether they work.

A Note To The Teacher: For/On Teaching The Activities

INTRODUCTION

These activities are not tightly structured lessons. The activities deal with energy transfer. You will have to be willing to improvise (a little), and sometimes depart on unplanned excursions when your students ask questions that do not lead in the direction in which the activities are pointed. You will have to decide whether such side-trips look promising and how far afield you and the kids have time for. Such leads offer exciting possibilities. Some of them may provide independent study projects.

The activities can be used in a variety of ways. Mostly, they are intended for individual/independent study and as projects for teams/small groups.

The success of the activities also depends on the instruction and reading assignments your class have had on three general types of heat transfer, namely, convection, conduction and radiation. It is left up to you to decide how to treat aspects of thermal transfer you think important: particle to particle, or molecules, and whether you do anything with the notion that energy of motion of the particles/molecules is dependent on their velocity (kinetic molecular theory).

Because the particles cannot be seen, details of the events occurring in conduction, convection and radiation, can only be inferred. This provides an excellent opportunity for you to help kids understand the use of models in science-building. You will probaly want to help be sure that students understand the difference between their observations and the inferences which follow from theory.

On Turning a Circus Into Thermal Physics

The three activities require that kids convert a problem into an investigation. You can do this by:

I. **Calling the Question**

- There is a certain tentativeness in science that is sometimes both difficult to understand and troublesome to young learners. Answers are usually couched in terms such as "given what we know that is probably true" (or false). Scientists are always (well, almost always!) open to new alternatives based on new information, techniques and reconsideration of data. There are many variables which can affect the outcomes of an experiment.

  Students should be expected to state hypotheses-to-be-tested. The form suggested here is used extensively in science and also in the social sciences. Hypotheses are statements of testable questions or a tentative explanation.

  The hypothesis begins with an **if** statement which is followed by a **then** statement. **If** air is heated in a mesh collector **then** it will be 5° to 10° hotter than air heated in a corrugated collector. If. . . then. . . Help your kids to learn to use them.

  The **if** or input part of the hypothesis is the variable which is controlled by the investigator. These kinds of variables are called independent variables. The **then** or outcome part of the hypothesis is the variable over which the investigator has no control. These kinds of variables are also called dependent variables.

Data from many experiments can be graphed. **If** variable data are plotted on the horizontal or x-axis. **Then** variable data are plotted on the vertical or y-axis because of the functional relationship between the data. The next step is. . .

II. Testing the Hypothesis

- Emphasize not only the variables in the system but more importantly the relevant variables. These are the variables they can control. They might be characteristics such as temperature and time, perhaps specifically the time intervals that observations are made.
- Operational definitions for the variables have to be constructed. What exactly will you measure? How will you measure the variable or variables? When will you measure the variable or variables? How often will you measure the variable or variables?
- How will you record your data (or findings. Some teachers do not like this word)?
- How will you represent your findings (or data)? Tables? Graphs? Histograms?
- What tentative conclusions can you reach about possible relationships among the variables to answer the question you are investigating?

Don't forget to do a. . .

III. A Postmortem on the Results

Don't miss an opportunity to discuss the experiments and the student experiences. In such discussions don't be judgmental but try to extend student understanding of science and science processes.

- What are some variables that you/we didn't control? How could these variables be controlled next time? Are there some variables that cannot be controlled?
- What are the performance data on some of the best/better investigations?
- How sure can you be that another person doing the same experiment would achieve the same results?
- Based on the entire class, collect all the class data for the investigation. How much variation is there? What is its range? What is its average? How could you have obtained more reliable or consistent data? What generalization can be reached using all the class data? Is this a better generalization than that of a single investigation?
- What is evidence? Is it information that in some way has bearing on the hypothesis? Is more evidence better evidence? How do you decide you have enough evidence?
- What is so useful about graphs? Can you make any predictions using your graphs?

ACTIVITY ONE

Materials Needed Include:

An assortment of plastic bags
An assortment of small jars, vials with covers or small milk cartons
Thermometers
Cardboard

Optional: mylar film
Colored cellophane
Rubber bands
Scissors
Back and white paper
Aluminum foil.

Ask your students to make a prediction about the future energy status of two systems: two equal containers of warm water—one in a roomy plastic bag; the other not. Now ask them to state a hypothesis which they can test.

If ____

then I predict____

Have them try it. Does the system behave as predicted? Why or Why not?
Based on their data what conclusions can they reach?
Now ask your kids to make

- their system lose heat more quickly,
- their system to heat more slowly.

ACTIVITY TWO

This activity asks students to solve a problem: Is lightweight, light-colored clothing energy saving. Some notes on teaching the activity precede the student assignment.

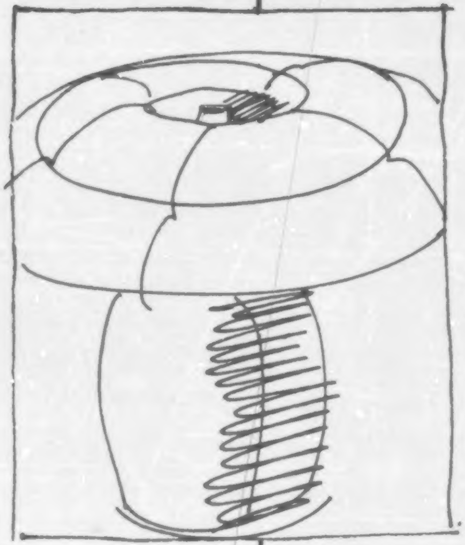
A Teacher/ing Note: For Sens(e)ible Office Clothing

A Little Back/ground

There are four channels of energy exchange between an organism and the environment: conduction, convection, radiation and evaporation. The first three are concerned with either a new loss or gain of heat; the fourth, evaporation, is generally considered to result only in heat loss. Evaporation results in the loss of "latent" heat required to vaporize water from the skin, the respiratory tract and active sweating.

Humans have been studied in the heat of the sun while nude and while wearing light clothing which is roughly equivalent to a coat of body hair. At rest or light work the clothes person gained about two-thirds as much heat as the nude person and sweated equally. This is roughly the same savings in heat gain that one gets from going out of the sunshine into the shade.

In open country, solar radiation becomes an important element. Even in the shade, air temperature rises, usually about 5° C, primarily from the heat radiated by the nearby ground which is in sunlight. Exposed sand or rock, for example, may reach surface temperatures of 60° C, a level painful to touch; the tips of the wool in sheep has been measured at 85° C in the desert sun, although their skin never reaches this level. Standing humans receive only two-thirds as much direct solar radiation as a standing sheep of equivalent size on a daily average. In humans, there is a dependence on thermal sweating for heat dissipation. Humans have the greatest sweating capacity area of any known animal.



About the Activity

Students are going to need help in solving this problem. Two of several experimental possibilities are suggested here.

1. You/your students may consider the possibility of making a model. (A "burnoose for a bottle." A burnoose is the hooded cloak worn by Arabs and Moors.) You could present this in the form of a challenge. Students could race suitably dressed containers of water under the direct heat load of the sun. May the coolest container win! This activity requires a collection of glass/metal containers; white paper; cloth; cardboard; thermometer; and a good "junk box." This particular approach could also precede the option discussed next.

   An extension of this approach would be to see if students can begin to separate how much of the heat gain is from direct sunlight, and how much is from the environment. For example, in what ways does the surface on which their model is located influence their experiment?

2. Other students may be interested in studying the effects of light/white clothing on live humans rather than working with a "model." The teacher directions which precede this entire sequence of activities provide an approach.

   Some kids might be interested in trying to simulate as closely as possible desert clothing. Sheets as well as standard white clothing could be tried. You may want to have students study the influence of a hood on the overall design, comfort and temperature of the garment.

3. During the activity ask students to research articles on clothing and the energy crisis.

   In 1974, John Sawhill, then director of the Federal Energy Administration, said that men could stay cooler if they stopped wearing ties. One response from a tie manufacturer was that s/he would like to wrap a tie around Sawhill's neck—tightly!

   This year, President Carter ordered thermostats raised to 78°F, many business and government agencies relaxed their dress codes to allow men to remove their ties at work. Governor William Clements of Texas even issued a proclamation declaring a "No-Tie Summer" for his state. But does it make a difference? Gerald Anderson, executive director of the National Neckwear Association, said: "If every man in America went without a tie, it wouldn't conserve one drop of oil." (St. Paul Pioneer Press, August 1, 1979.)

   Do you and your students agree or disagree? Based on your experiments what are some of your reasons: (Did anyone put a tie on the model to try it?!)

   Suppose an Arab or a Moor, one used to wearing desert clothing , was asked the questions listed below. What do you think the response would be?

   Wearing a tie will make you feel warmer.

   Wearing a tie will make no difference about how you feel.

   "If every man in America went without a tie, it wouldn't conserve on drop of oil."

THE ASSIGNMENT:

Read the following statement to your students.

On Wednesday, June 6, 1979, Japanese Prime Minister Masayoshi Ohira modeled an "energy-saving" lightweight, light-colored suit in Tokyo. The Japanese government is trying to persuade businessmen to wear such suits, instead of traditional dark ones, to save on air-conditioning this summer.

Ask students whether they think it will keep workers cooler? Is the suggested effect real? Is it measurable? You may want to remind them that people wear white clothing in the tropics and deserts. (Do people in the tropics really wear white clothing? As an assignment you may want your students to verify this.)

Does such clothing in fact keep tropical and desert residents cooler?

Ask your class/students to design an experiment which proves to everyone's satisfaction that the suggested effect is real and measurable or not.

ACTIVITY THREE

You Will Need:

A cold Minnesota winter day

Students inside (Thermostat at 65°F or lower—of course!—sweaters, long underwear)

A large window

On a cold day, ask students to face a large window at home or at school for 15 to 30 seconds, quietly and attentively. (Schools usually have excellent windows for this.). Have them turn 180° for 15 to 30 seconds.

In which position did your face feel cooler?

My face:
felt warm(er) when ______________________
felt cool(er) when ______________________

Tally the responses.

Do it again and tally the responses, if any.

Note the differences, it any.

Does the air temperature change as you turn around?

Develop a hypothesis which explains the observation.

What measurements can you make to find out more about what is going on?

RE/SOURCES

Anonymous. 1979. Tie Makers Keep Cool While Office Temps Rise. St. Paul Pioneer Press. August 1 (Article from Los Angeles Times).

Fast, Julius. 1979. Weather Language. Wyden Books. Distributed by Simon and Schuster, Inc., New York. (Chapter 7. Body types, clothing and personality).

Goodman, Ellen. 1979. Sensible Office Clothing for Men—at 78 Degrees. Minneapolis Tribune. July 31.

Mead Margorie. 1979. Saving Energy With What You Wear. Illinois Circular 1168. Cooperative Extension Service, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

Solar Energy Research Institute. 1979. Reaching Up, Reaching Out: A Guide to Organizing Local Solar Events. pp. 22-23 in "Dress Up - Dial Down." (1617 Cole Boulevard, Golden, CO 80401. $8.50 from US GPO).

TOYS: CONVERSION KITS

WHAT IT'S ABOUT

This activity assumes that by means of lecture and/or film and/or laboratory experiences and/or reading and/or other class experiences, your students have been introduced to some major areas about energy. This includes **kinds:** potential energy and kinetic energy; **forms:** chemical, electrical, mechanical, radiant, atomic, gravitational and, possibly, translational (or linear) rotational and elastic; and **energy transformation,** or the processes by which energy changes from one form to another.

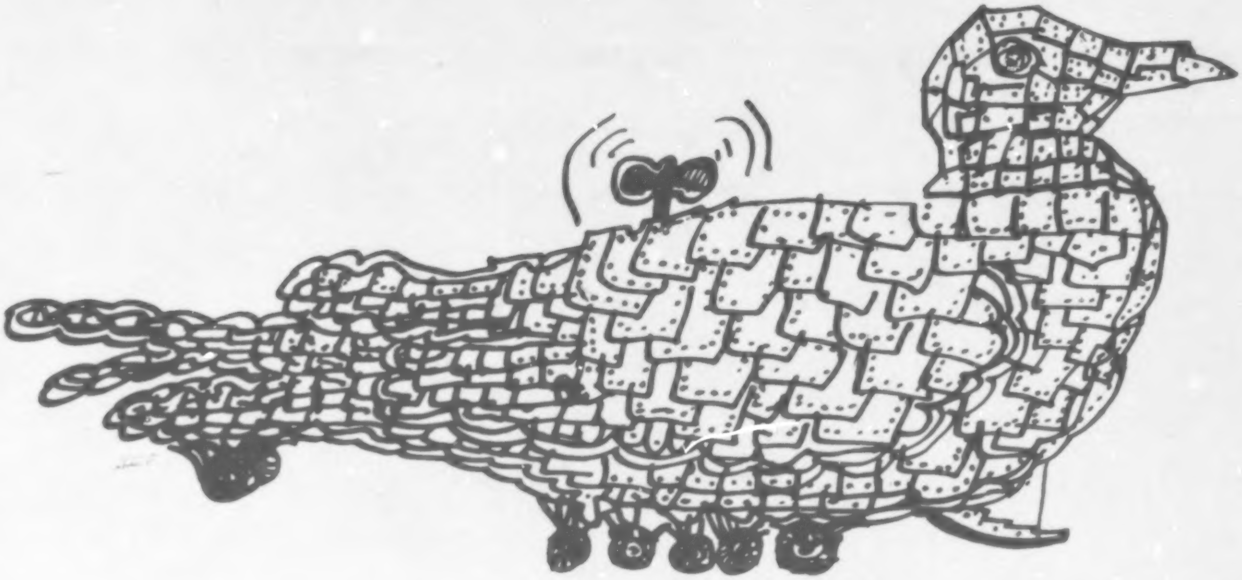
This activity is a blend of the old and new physics; it certainly will not provide an explanation or consideration of all forms of energy but will, it is hoped, contribute toward a basic goal of science and energy education: the development of scientific and energy literacy. I will also survey students' understanding of some key energy concepts. The experiences here should serve as a reinforcement for discussions and class experiences you have had on the kinds and types of energy conversion, and on energy conversions.

Activities include:
(a) a paper airplane contest,
(b) students illustrate how a familiar toy uses energy,
(c) students design simple toys that operate utilizing simple energy concepts.

Grade Levels: Junior High — Physical Science

BEST COPY AVAILABLE

TOYS: CONVERSION KITS



ENERGY CONTENT AND STUDENT OUTCOMES: Some Notes On This Unit

Obviously, it is a good thing to think about what students might get from the work in this activity. What will they achieve through their involvement it it? Clearly, teachers are in the best position to decide what knowledge, skills, and attitude development are best suited to their students. With this in mind some possible outcomes are listed below. The listing is only one of a large number of possible selections. Each of them can be achieved in many different ways. The achievement of many of the objectives is probably accumulative rather than through single experiences and it is also dependent on the classroom management of the process.

SOME BACK/GROUND NOTES

The physics of toys present a wide variety to problems related, often somewhat tenuously, by virtue of some connection to energy. What can be learned about energy from toys? A complete listing is impossible but it would surely include the following: the nature of forces between electrostatically charged objects; propellor dynamics; work multiplication through gears; energy storage; conversion processes; the nature of frictional losses and rates; the principle of conservation between linear velocity and the distribution of mass of an object; changes in potential energy and kinetic energy; movement requires energy; properties of electrical and mechanical energy; energy is conserved when it is changed from one form to another; and appreciation of some of the social implications of human's changing use of energy.

Toys represent a remarkable potential for learning about energy. Some of the energy events and principles are easy to observe and understand; others are hidden from view and some are very difficult to answer. Toys can provide a place to start for learning about energy or as part of other investigations into the nature of energy and energy processes. It is hoped that experiences with toys will help contribute to students thinking about other practical applications of physics and energy, providing them with some additional interpretive tools.

ACQUIRING:

WHAT IS TAUGHT	Knowledge	Learning Skills	Attitudes	LEADING TO GENERALIZATIONS
Energy Kinds	*Potential Energy	*How to analyze energy conversions.	*Problems are fun.	*Energy is taken during energy transformations.
Energy Forms	*Kinetic Energy	*How to turn a problem into an experiment.	*Physics and energy problems are to found in the real, everyday world and I can learn to understand them (to varying degrees).	
Energy Transformation	*Mechanical Energy	*How to identify select variables for measurement.		
Analysis of energy systems from the point of view of energy conversion	*Electrical Energy	*How to take appropriate measurements.		
Problem Solving	*Translational Energy			
	*Rotational Energy			
	*Elastic Energy			
	*Processes of energy conversion			
	*The role of chance in making measurements			
	*Energy can be stored and converted			

ACTIVITY ONE

This activity emphasizes problem solving. It is a somewhat open-ended problem-solving situation designed to precede and prepare students for the activity which follows: the energy analysis of a toy.

The diversity of reactions to the problem presented will vary widely. Some students will set right off doing some of the most ridiculous experiments with no planning or thought. Some students may argue with one another about what they are trying to find out, and whether or not a particular device or modification will, indeed, solve the problem.

Your role, at this point, will range from simply observing and offering no assistance to asking questions about what students will accomplish by following a particular procedure they have proposed.

To introduce this activity, launch a paper plane and let it glide through the room. Ask students to identify the energy source, the energy receiver, and evidence of energy transfer. Ask them to list the variables which influence the flight of the paper plane. After you have completed this brief survey of your student's ideas on energy, divide the class into small groups of three or four and present them with this problem:

> Design a paper plane with the best performance characteristics. Materials are to be limited to standard sheets of paper and paper clips.

A Teacher/ing Note:

Some Things You Can Do To Help Students In The Great Paper Airplane Contest

You will have to decide where you are going to launch the planes. Corridors and the gymnasium are two possibilities. You may also want to give students an idea who the "competition" is. According to a report in **Energy Insider** (March 31, 1980), "A paper airplane which flew a distance of 49 feet and another which stayed aloft more than 10 seconds were winners in the recent Fourth Annual Great Oak Ridge Paper Airplane Contest. The American Museum of Science and Energy, sponsor of the event, converted its lobby and corridors to runways which were lined with more than 1,200 spectators and "pilots." About 125 registered "pilots" entered various events.

A. What variables make up a good performance:
  - Height plane reaches?
  - Distance plane flies?
  - Time plane stays in the air?
  - Accuracy plane has in hitting a target?
  - Longest arc plane flies?
  - Most loops?
  - Fastest climber.
  - All of the above or some combination?

Discuss ideas of reliability and unreliability (scatter of landing patterns); skill and the operation of random factors (large target vs. small target); launching techniques (height, fixed launching platform vs. hand launched).

B. How will you measure the variables?
  - What do you measure? Range? Height? Accuracy?
  - How display the results? A graph of range versus height? A histogram of accuracy?

C. Should you construct two planes and fly them or work only with one plane?
  - How many trials?
  - Variability. Between planes. For each plane.

D. After students have collected data in C., discuss the results with them.
  - Variables influencing flights. Does it suggest modification in design? What is the influence of launching procedures? What can they do to produce more consistent results?
  - Review the performance criteria with them.

E. What modifications produced the better performances?

F. Ask each of them to carefully describe, then summarize the data on their best model.

G. Is there a relationship between launching height and performance? What is it? Can you use your graph for prediction, e.g., if the airplane has a certain range, what would be its height or if the airplane has a certain height, what would be its range?

MORE

HAVE A CONTEST among members of groups (Height Group, Distance Group, Time-Plane-Stays-in-Air-Group, Accuracy Group).

- Increase the materials and design options, e.g., paper types, paper weights, wing spans.
- If you have students who are interested in paper helicopters, two designs, made from 3x5 cards may be found in an article "Use 3-By-5 Cards to Get Kids Thinking," by Professor Odvard Dyrli. (See Re/Sources.) The helicopter provides interesting possibilities with the addition of different variables. If the rotating rate is changed will the helicopter fly longer? Does the direction the helicopter rotates (clockwise vs. counterclockwise) influence air time?

ACTIVITY TWO

Two teaching/learning options are presented: (1) students present an analysis of a toy by means of a poster session; and (2) students analyze energy conversion systems as a class laboratory experience.

Poster sessions are used widely at scientific meetings. Their first appearance in the United States was in Minneapolis in 1974 at the Biochemistry/Biophysics Meeting, cosponsored by the American Society of Biological Chemists and the Biophysical Society.

Poster sessions have been found to be a better way of presenting formal scientific papers. At scientific meetings participants remain with the display for a set period — an hour or so — to discuss the material and answer questions.

A. This can be an individual assignment or you can divide your class into groups of two students an let them create a poster on which they place graphs, diagrams, data, drawings, pictures and a small amount of text to illustrate the main points of a presentation they make to the class on a favorite toy (theirs or that of a younger brother/sister!) or energy conversion device.

Students are to carefully analyze the toy or device they choose, and, their poster/talk should include an energy chain model of all energy conversions involved in its operation. The cahin, a sequence of energy events, can be written, symbols (PE ⟶ KE ⟶ . . .), diagrams/pictures, or a combination of these can be used. Two or more energy transfers, in sequence, are called an energy chain. The sequence, in energy chains, is from the first to the last energy transfer.

For each device the student should also clearly identify the energy source, the energy receiver and evidence of energy transfer; and the variables which influence its functioning.

Some toys can be used to demonstrate physical laws, e.g., Newton's Second Law of Motion. Other toys offer opportunities for scientific investigation and problem solving. Suppose a student chooses a "friction-powered" toy.

There are opportunities to investigate: (1) the linear relationship between the changing speed of the toy and the speed of the flywheel; (2) how many times farther the toy travels at a higher rotational rate than at a lower rotational rate; (3) the role of friction; (4) the calculation of work (joules) done in hill climbing; (5) the influence of having a flywheel mounted vertically versus a flywheel mounted horizontally; (6) using flywheels in transport systems of the future (see Re/Sources); and (7) the advantages and disadvantages of flywheel-powered systems. This list is not by any means a complete one but it suggests possibilities. Insists that your students make their reports as complete as possible.

In addition to toys there are also some other possible energy conversion devices for your and the class to consider:

a. Musical instruments;
b. Radiometer and other "metering" devices, e.g., pendulum;
c. Common household devices, e.g.,
- incandescent light bulb;
    - flourescent light bulb;
    - whistling tea kettle;
    - percolator-type coffee maker;
    - green plant;

d. Low-resistance telephone earpieces connected with a flexible wire or tin cans connected by wire/string.

B. Class Laboratory Exercise

Place the Energy systems—a dozen or so—in the labroom. Use a mix of toys, household devices and some standard physics/physical science equipment (a coil, magnet and metering device) to reinforce the idea of energy conversion and to increase the range of awareness of students in their ability to analyze energy converting systems.

For each of these students are to:

SPECIFY:

a. the energy source,
b. the energy receiver.

PROVIDE:

evidence of energy transfer.

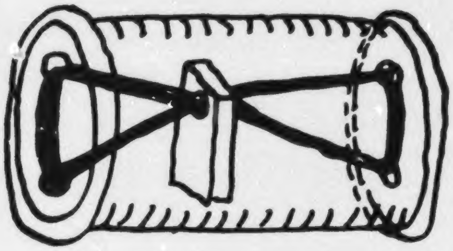
DEVELOP:

an energy model of all energy conversions.

ENERGY

kind and forms (kinetic energy, potential energy, thermal energy, gravitational potential energy, electromagnetic energy, electro-static potential energy, chemical potential energy, potential difference or voltage, radiant energy, mechancial energy and atomic energy).

ACTIVITY THREE



The "Super-Great Come-Backio or El Returno" Can Competition.

Materials needed: a can, can ends, elastic (rubber bands, tubing), weights, scissors.
A Return Can

Put two holes in the bottom and top of a can and string a rubber band through them. Suspend a weight in the middle of the can from both pieces of rubber.

Teacher Demonstration
Roll the can. What happens? Ask students to explain what happens. What is the energy source? The energy receiver? The evidence of energy transfer? What are the variables that influence this device?

Is the distance the can rolls the same out and back? Why or why not? Try this at least ten times. How much variability is there in the outcomes? What is the best way to display the variability? Where is the energy when the can stops?

Class Activity
Engage your class in a friendly competition. Choose one of the following possibilities. Design a can that goes the farthest, is the quietest, is the largest (within reason), is the smallest, goes the fastest or goes the slowest. Use the teacher suggestions in activity I to help students design their car.

Can more energy be stored in the twisted rubber band than the system uses in rolling? How could you find out?

The "Rollback Bunny" is an example of a toy based on the principles of the roll-back can. If some of your students have this or a similar toy at home ask them to bring it in. In what ways are these systems alike and different?

ACTIVITY FOUR

A Simple Motor
For this activity students will need an elastic motor from an old model airplane. Some of the investigations may be easier to conduct if the motor is mounted on a stand.

Student Card: A Simple Elastic Motor From A Model Airplane

What variables influence its performance?

How long does the motor run? How much variability is there in ten trials? Twenty trials? Show the results of these trials.

What can you do to obtain more reliable or consistent results in making the motor run? Try it. How successful were you?

Make the motor run longer.

If you double the length of the elastic what do you do to the duration that the motor runs? Make a prediction and check it out.

If you double the elastic on itself so that it consisted of four strands instead of two, would this influence the duration that the motor runs? Make a prediction and check it out?

MORE

1a. Racing car sets (slot cars, etc.) provide many opportunities to explore energy relationships with their banked tracks and loops.

  In what ways does rate vary with car mass?
  What are the effects of wind resistance on model car designs?
  What are the effects of friction? How can it be reduced?

b. Engineless cars (including those with a power booster) also provide endless opportunities to investigate, e.g.,

- What are the variables involved if we wish to increase the rate of speed of the car?
- The effects of friction on distance the car travels; on rate of speed?
- Experiments to show that moving bodies tend to move in a straight line.
- Ways to measure energy input (calibration) and output (how far will car go, how far will it climb an inclined plane.)
- The influence of loading (adding weights) on speed of the car, distance it travels, acceleration.
- The influence of banking on the car-track system. What happens to the cars if the curves aren't banked?
- What happens to a car after it passes over a simple bridge in the system (a block of wood under the track)? Does it leave the track? Where? Why? Does the car slow down after it goes over the bridge? Why?
- What is the relationship between starting level and distance traveled? Rate of speed? Acceleration? Is there a maximum height beyond which height makes no difference in distance traveled? Rate of speed? Acceleration?
- What is the relationship between hill steepness and speed? Distance traveled? On acceleration?
- If you have two tracks of the same length, each with different slopes, one concave and the other convex, which would be the fastest? Which accelerates the car the fastest? Which maximizes the distance traveled?
- If you freewheel a car down a hill, how far up the other side will the car go before it comes to a rest? Higher, lower, the same level as the start? What are the reasons? Is it the same for all trials?
- What is the largest diameter loop you can make and still keep the car on the track? If you double the starting height, can you double the diameter of the loop?

RE/SOURCES

Armagnac, Alden P. 1970. Super Flywheel to Power Zero-Emission Car. Popular Science. August, pp.41-43.

Blasi, Rocco C. (Ed.). 1974. Physics Fun and Demonstrations with Professor Julius Sumner Miller. Second Edition. Central Scientific Company, 2600 S. Kostner Avenue, Chicago, Illinois 60623. ($16.95).

Dyrli Odvard Egil. 1979, Use 3-By-5 Cards to Get Kids Thinking. Learning, April, pp.62-63.

Mander, Jerry, George Dippel and Howard Gossage. 1967. The Great International Airplane Book. Simon and Schuster, New York. ($2.95).

Post, Richard F. and Steven F. 1973. Flywheels. Scientific American. Volume 229, Number 6 (December), pp. 17-23.

Walker, Jearl. 1975. The Flying Circus of Physics. John Wiley and Sons, Inc., New York. ($8.95).